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- > Pre-Primary Tutor for Kids
- > Arduino Piggyback on Raspberry Pi
- > Museum Watchdog

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contents

ELECTRONICS FOR YOU PLUS | APRIL 2015 | VOL. 3 NO. 12

TECH FOCUS

36 5G Technology
to Benefit Cyber
Physical Systems



BUYERS' GUIDE

72 Prototyping, Designing
with FPGA Boards Made
Affordable and Absorbing



20 **Futuristic**
Tele-immersion: The Death of Distance

28 **Design**
The Making of a Radio-Controlled Plane

32 **Tech Focus**
Your Phone, Your Network, Your Apps:
Everything Would Change by 2020

40 **Telecom**
IMT: Advanced Requirements and
4G Candidate Technologies

46 **Sensors**
An Introduction to Wireless
Multimedia Sensor Networks

52 **Test & Measurement**
New T&M Tools for Academia
Boost Learning, R&D and Industry
Readiness

58 **Innovation**
Control Everything with Your Hand

Embedded

62 To Go Boldly Where No Board Has
Gone Before

68 Better Integration and Enhanced
Software-Driving Programmable ICs

76 **EFY Plus DVD**
This Month's DVD Contents

78 **Defence Electronics**
Precision-Guided Munitions:
Infra-Red-Guided Weapons (Part 3 of 4)

DO-IT-YOURSELF



- Wireless Hotel Ordering System.....92
- Museum Watchdog96
- Wireless Low-Cost Luggage Security Alarm97
- Simple Light and Sound Indicator
for Mains Power Supply99
- Air Motion Detector100
- Arduino Piggyback on Raspberry Pi101
- Pre-Primary Tutor Using Arduino103
- Designing an 8-Bit Arithmetic
Logic Unit Using ModelSim105

87 **Interview**
“We are running in fog and it
is getting denser” — Sunit Rikhi,
vice president of the technology and
manufacturing group and general manager
of Intel Custom Foundry, Intel Corp.

88 **Interview**
“Could cause missiles to misfire, radar
systems to crash”
— John Cronin, vice president of operations,
North Shore Components Inc.

112 **eStyle Buyers' Guide**
Headphones for Enjoying Quality
Music all the Time

114 **EFY Expo India 2015**
Celebrating the success of the Indian
ESDM industry

122 **Make in India**
Market Survey: Green Power Backup
Solutions will be the Next Big Thing in India

EDITOR	: Ramesh Chopra
EDITORIAL	: Editorial Secretary
CORRESPONDENCE	: Phone: 011-26810601; E-mail: editsec@efy.in (Technical queries: eflyab@efy.in)
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PUNE	: Ph: 020-40147882 E-mail: eflypune@efy.in
GUJARAT:	: Ph: 079-61344948 E-mail: eflyahd@efy.in
CHINA	: Power Pioneer Group Inc. Ph: (86 755) 83729797, (86) 13923802595 E-mail: powerpioneer@efy.in
JAPAN	: Tandem Inc., Ph: 81-3-3541-4166 E-mail: tandem@efy.in
SINGAPORE	: Publicitas Singapore Pte Ltd Ph: +65-6836 2272 E-mail: publicitas@efy.in
TAIWAN	: J.K. Media, Ph: 886-2-87726780 ext. 10 E-mail: jkmedia@efy.in
UNITED STATES	: E & Tech Media Ph: +1 860 536 6677 E-mail: veronique.lamarque@gmail.com

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EFY Plus DVD

GNU Radio: An Open Source Software Radio Ecosystem	I
IRSIM: A Switch-Level Circuit Simulator	IV
nano-archimedes: A GNU Package for	VII
Nano-World Simulations	

Regulars

06	Feedback
08	Q&A
10	Useful Websites
14	Tech News
110	First Look
118	Make in India: Industry News
126	New Products
129	Business Pages Ads
139	Electronics Mart Ads
148	Product Categories Index + Attractions During 2015
149	Advertisers' Index

NEXT ISSUE

• Virtual Electronics
(on Web)

• Telecom & Electronics

• 3D Printers
(Under ₹ 100,000)

Physics Nobel Prize

In 'Physics Nobel Prize 2014 for LEDs as Future Lighting Devices' article in January issue, while explaining about PN junction (page 26) it is given that when no voltage is applied, a depletion region is formed. But should it not be so when voltage is applied?

Pooja Math
Kalaburgi

The author Dr S.S. Verma replies:

That is correct! The formation of the depletion region in PN junction is formed when no voltage is applied.

In continuation to what follows in PN junction formation across the crystal is, there is a concentration gradient of holes and electrons. Holes that are in majority on p-side are minority carriers on n-type; and vice versa for electrons. Concentration gradient causes diffusion of charge carriers (holes and electrons) across the junction even without applied voltage.

Holes will diffuse from p-side to n-side, and electrons will diffuse from n-side to p-side. Some holes on p-side will combine with electrons that have diffused from n-side (some holes will disappear). This leaves un-neutralised acceptor ions (negative ions) near the junction on p-side.

Similarly, some electrons on n-side will combine with holes that have diffused from p-side, leaving un-neutralised donor ions (positive ions) near the junction on n-side. Thus, there will be an accumulation of positive and negative ions near the junction called depletion region.

PLL FM Transmitter

I am interested in 'PLL FM Transmitter' circuit published in December 2014 issue. I am stuck at RFC (RFC1 and RFC2) and balun cores? Please explain in detail about RFC and L2, and tell me how to make these, or where these are available?

Rushiraj Jawale
Mumbai

The author Joy Mukherji replies:

RFC1 and RFC2 are wound on two-hole

'Spot An Error' Award Winners

In 'Precision-Guided Munitions: Guided Techniques' article under Defence Electronics section of February issue, under 'Types of guided weapons,' it is mentioned 'anti radiation weapons (ARMs),' but it should be anti radiation missiles (ARMs).

Siddharth Kaul

❑ In 'Building Connected Internet of Things Widgets with Raspberry Pi and Intel Galileo' article in February issue, there is an error under 'Comparison between Galileo and Raspberry Pi Model B+'. GPIO pins for Raspberry Pi B+ are given as 26 instead of 40.

Tejas S. Hortikar



Fig. 1: Balun cores

It can be made using two ordinary ferrite beads placed side-by-side, if binocular balun core is not available. Ferrite balun cores available in various sizes are shown in Fig. 1.

Pendulum Clock

In 'Javascript Based Canvas Pendulum Clock' DIY article published in February issue, the screenshot (Fig. 2) on page 124 is wrong. An error message is supposed to pop up if Internet Explorer (IE) is used but, instead, it is asking for the default browser. When a script is not supported in IE, it should not show anything.

Monish Meher
Vashi

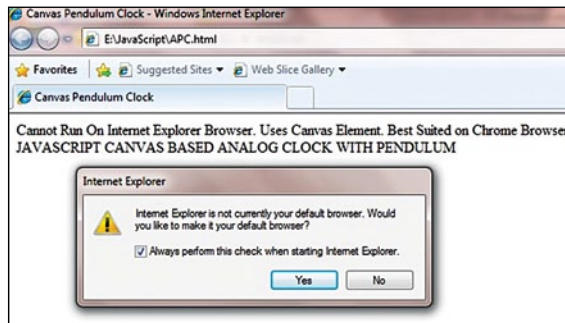


Fig. 2: Error message

Errata

In 'Buyers' Guide' on modern multimeters in March issue, under 'Notable Multimeter Brands' (page 57), Rigol has been misspelled as Rigel.

binocular TV balun cores. These are generally used at the back of a TV for interfacing with the feeder wire. These can be replaced with ready-made moulded RF inductors.

RFC1 is critical as it prevents the PLL reference tone of 1.5625kHz from entering the RF section of the transmitter via the power supply. Any value between 1mH and 5mH will do. RFC1 in the prototype is measured at 1.5mH. Use a 40µH to 100µH moulded choke for RFC2. RFC2 is not critical and can be eliminated altogether.

L2 is a simple broadband transformer wound on a TV balun core.

The author Sridhar Bukya replies:

The screenshot is correct. If you have installed more than one browser, say, IE and Google Chrome, on your PC, and if these are run for the first time, the message asking which browser should be used as default pops up. 'Cannot Run On Internet Explorer Browser' error message is shown along with other messages. The same is reproduced here in Fig. 2.

.html and .htm files both run on these browsers. IE versions lower than 11.0.9600.16438 may not support <canvas> element. I have run and tested the project on Google Chrome version 40.0.2214.111.

For older versions of IE, the page will return blank as it does not recognise <canvas> element.

Things You Wanted to Know!

Q1. I want to start making electronic items for which I need soldering machines, stations and other components like LEDs and resistors. I request you to send me some details regarding the same.

Jaswinder Kaur
Ropar, Punjab

A1. You will find the necessary information on sources of supply of components and instruments in EFY Electronics Industry Directory. You can also get information online from our website www.eleb2b.com

For soldering machines, you need to know parameters like tip temperature, tip-to-ground resistance, solder pot temperature and ambient temperature, among others.

Parameters for selection of LEDs are colour, viewing-angle characteristics, forward and reverse voltage luminous intensity and package, among others.

Resistor parameters to be considered include type, wattage, tolerance, voltage rating, temperature coefficient, stability and others.

Q2. What should be the capacity of the battery for a 100-watt solar panel with three-hour run time?

Ram Mohanty
Cuttack, Odisha

A2. For 100W load and three-hour runtime with a margin of 25 per cent, the rating of the inverter would be 125W. Capacity of the battery should be $3 \times 125 = 375\text{Wh}$. So we have to use two batteries of 200Wh ($2 \times 200 = 400\text{Wh} > 375\text{Wh}$) each.

Q3. I would like to know the features of 3-bit-per-cell (X3) technology.

Ashish Mulajkar
Pune, Maharashtra

A3. 3-bit-per-cell (X3) technology relates to flash memory structure. Flash memory has been available for the last few years with single-level cells having 1-bit storage per cell (SLC) and 2-bit per cell multi-level cell (MLC).

Multi-level cell flash is a type of flash memory that stores more than one bit per cell. The ever-increasing digital data places an increased demand for NAND flash memory, which has led to the development of X3 technology. It is co-developed by SanDisk and Toshiba, which shares with SanDisk the development and manufacturing of advanced flash memories.

The memory-tiered structure is shown in the figure below. X3 technology requires no change in the basic design of flash memory from a manufacturing viewpoint. With the same process technology, X3 provides more bits per wafer and lower cost per bit. Thus, the cost reductions per

sumption is less in SLC/MLC. MLC flash is less expensive than SLC, which makes it a popular choice for consumer-grade solid-state storage.

Q4. The 3-pole electronic relay with sufficient current rating is available, but generally it is not used to operate the 3-phase, 400V AC, 5HP induction motor. Electric contactors are widely used to operate it. Please explain why relays are not used?

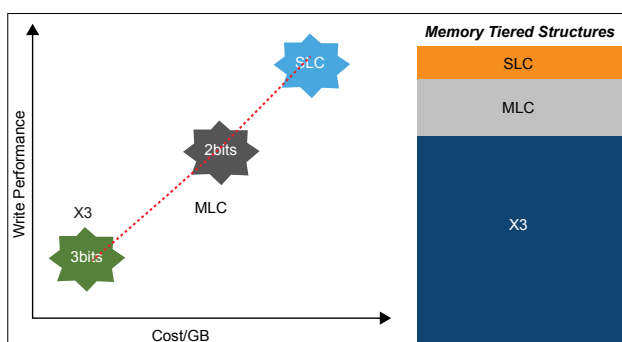
S. Chinnadurai
Salem-DT, Tamil Nadu

A4. Relays and contactors are electromagnetic switches. The only difference is that relays are usually used for low-voltage applications, while contactors are used for higher-voltage applications. Contactors with accessories like start, stop buttons and overload relays provide integrated solutions for starting and controlling operations of 3-phase AC motors.

Direct online starters using contactors are available as single units, which can easily be mounted on control panels. Contactors have larger-size contact strips, which are capable of carrying more current. The distance between

contact strips is also more, therefore capable of withstanding higher voltages.

Relays are normally used in appliances below 5kW, while contactors are preferred when the appliance is heavier in terms of current requirement. Further, relays are cumbersome to use when compared with contactors.



Memory-tiered structure

bit can be significant using X3. This technology also maintains low cost as shown in the figure.

Write performance is better in SLC/MLC as shown in the figure. Read performance in X3 does not differ much between SLC and MLC. The more bits the cell has, the fewer write cycles it will have. For example, a 2-bit MLC cell is good for about 3000 to 10,000 write operations before it begins to fail, while a 3-bit MLC cell would only have 300 to 3000 write cycles. Once a cell is written to its limit, it starts to forget what is stored and can corrupt the data. Power con-

Answers compiled by EFY joint director (training), Col. N.C. Pande (Retd). Letters and questions for publication may be addressed to Editor, Electronics For You, D-87/1, Okhla Industrial Area, Phase 1, New Delhi 110020 (e-mail: editsec@efy.in) and should include name and address of the sender

Open Source Hardware

Open source hardware (OSHW) consists of physical hardware designed and offered in the same manner as free and open source software. Here are a few websites that will introduce you to some commonly available OSHW

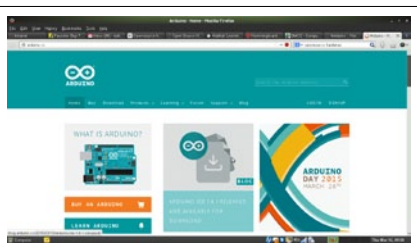
NIRAJ SAHAY

solid-run.com

This website has complete information on the new HummingBoard, a small, powerful, low-cost ARM computer. This OSHW allows you to run many open source operating systems, such as Ubuntu, Debian and Arch, as well as Android and XBMC. With its core technology based on SolidRun's state-of-the-art micro-system on a module (MicroSOM), it has ready-to-use open source images, and its open hardware comes with full schematics and layout. The website provides you with complete documentation and video tutorials on how to use HummingBoard.



<http://www.solid-run.com/products/hummingboard/>



www.arduino.cc

Arduino is an open source physical computing platform based on a simple microcontroller board. The official Arduino website has a section where you can find a list of do-it-yourself project ideas based on this OSHW. The list is helpful for both the novice and the experienced. The project ideas section has been divided into three categories for easy navigation. The categories include easy, intermediate and advanced.

<http://arduino.cc/>

oshwa.org

The Open Source Hardware Association aims to be the voice of the open hardware community, ensuring that technological knowledge is accessible to everyone, and encouraging the collaborative development of technology that serves education, environmental sustainability and human welfare. The website educates individuals and general public about OSHW. It also encourages collaborative learning, knowledge exchange and social cohesion through details of conferences and other events focused on OSHW.



<http://www.oshwa.org/about/>



beagleboard.org

BeagleBoard is a low-power, low-cost, fanless single-board computer. It is based on Texas Instruments processors featuring ARM Cortex-A series core. beagleboard.org is an all-volunteer activity started by a group of passionate individuals, including several employees of Texas Instruments, interested in creating powerful, open and embedded devices. The website has a discussion board along with links that provide information regarding where you can buy the board. It also has around two hundred different projects related to the board.

<http://beagleboard.org/>

opencores.org

OpenCores is one of the world's largest site/community for development of hardware IP cores as open source. OpenCores.org hosts the source code for different digital hardware projects (like, IP-cores, SoCs and boards) and supports users with different tools, platforms, forums and other useful information. The community is continuously growing and new people and companies from all over the world are registering their profiles and projects at OpenCores. You can explore it to understand how it works.



<http://opencores.org/>

TECHNOLOGY AT YOUR SERVICE

The world's first solar-powered aircraft takes flight

The world's first solar-powered aircraft, Solar Impulse 2, took off from Abu Dhabi, UAE, on its maiden journey around the world. The plane was built in Switzerland and took off from Al Bateen airport with the company's founder, André Borschberg, along with the company's co-founder Bertrand Piccard on board.



Solar-powered Solar Impulse 2

Project developers have said that the aim behind this airplane is to stress on the importance of giving up polluting technologies and opt for greener and clean technologies in aviation. Solar Impulse 2 features 17,428 photovoltaic cells that can capture the sun's energy. These cells can charge the four batteries that power the electric engines responsible for the thrust of the aircraft. The wings are 72m long and the aircraft weighs 2300kg.

Two pilots will pilot the aircraft taking turns during the 35,000km flight and will make stops at Oman, India, Myanmar and China, followed by crossing the Pacific and reaching Hawaii, the USA. The plane will then cross the Atlantic to enter Europe and Morocco before the trip comes to an end in Abu Dhabi.

The plane can reach altitudes of 8500m during the day to capture sun's rays, and during night it can drop down to 1500m while flying over the ocean.

A 3D-printed open source Raspberry Pi-powered robot

3D printing technology is being used in our lives in amazing ways. Desktop 3D printing is a common trend now and is slowly heading towards convergence between 3D printing and robotics. The credit-card-sized

Raspberry Pi has been of great help, along with the affordability factor of desktop 3D printers. Now, with the help of these two, people can create their own robotic devices. That is how Pi Tank, the robot, was born.

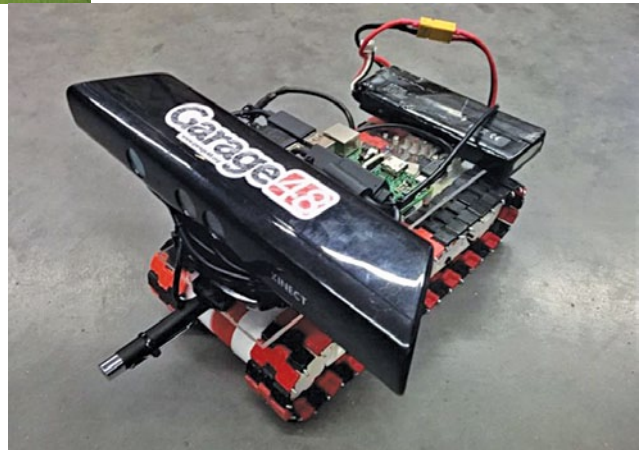
Pi Tank is a product by Madis Kaasik and his team, and is a result of 3D printing. It was a challenge for the team to come up with something unique, and that is when they came up with a 3D-printable Raspberry Pi open source tank robot that utilises a Microsoft Kinect

sensor. Pi Tank took inspiration from Parrot Drone app and would allow users to easily see what the robot is seeing at any given time.

After completing the design work, the team started with 3D printing the robot using Mass Portal Pharaoh Ed 3D printer, which was provided to all participants of Garage48 event, where the team was also participating.

Microsoft Kinect allows 3D scanning of objects too. The robot is powered by four geared motors, Raspberry Pi 2, Wi-Fi dongle, Arduino Uno, 12V-to-USB board, S3 2200 LiPo battery and L298n motor driver board.

Pi Tank aims to create a robot that can do whatever you want it to. Developers behind



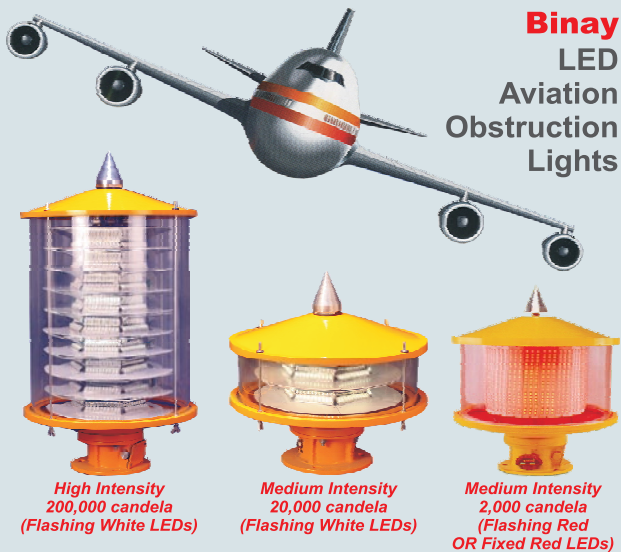
Pi Tank robot

the project are Ilya Kuzovkin (programmer and app developer), Ulf Anso (programmer, electronics and mechanical engineer), Kristjan Jarvan (team lead, marketing) and Madis Kaasik (mechanical engineering, design, CAD and 3D printing).

Objet260 dental-selection 3D printer takes digital dentistry to the next level

The versatile new 3D printer is designed to help mid-to large-sized dental and orthodontic labs grow their businesses by producing realistic models with true-to-life

BINAY - Lighting Up The Future



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THE BINAY LED OBSTRUCTION LIGHT IS UNDER ACCEPTED PATENT, AND AS SUCH IS A PROPRIETARY PRODUCT

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POWERING LED TECHNOLOGIES WORLDWIDE SINCE 1983

look and feel as part of their end-to-end digital dentistry work-flow, including intra-oral scanners. Its ability to build diverse models with multiple materials on one tray in one print job increases productivity, which can further improve profitability.

The printer is compatible with all PolyJet dental materials, plus an array of dental-specific material palettes to produce life-like colours and textures for teeth and gums. This allows users to serve a broader range of dental applications with a single system, reducing equipment costs. These usages span implant testing with stone models that mimic the look and feel of real gingiva for accurate functional evaluation, as well as models with rigid features that require gum-like materials. Labs can print surgical guides directly from CBCT scan data, with high-definition tooth, root and nerve-canal anatomy rendered in contrasting materials to help prevent dental nerve injury.

Goodyear unveils electric car tires

The new tyres for electric cars from Goodyear are capable of recharging the car's battery through tire heat and friction. The BH-03 aims to tackle some issues of shorter journeys in an electric car and offer a new way to recharge on the fly.



Goodyear BH-03 concept tyres

Shown at the 2015 Geneva International Motor Show, these new tires will add a few extra kilometres on each journey and recharge the car while it is parked.

Among the big factors limiting the popularity of electric cars are long journeys and if electric motors will last long enough. Lack of electric recharging stations is another issue. Goodyear's new tires aim to tackle both these issues.

However, these will only be useful in places where the temperature is warm most of the year, since the tires would not heat up if there is no heat. The friction while driving will be available regardless of climate, but it is yet to be seen how much energy this friction can generate.

Goodyear also unveiled Triple Tube tire, which is capable of adjusting tire inflation on the fly, depending on the type of road. It removes the need for multiple tires when going on multi-terrain drives.

The company has not named any partners for BH-03, but Tesla Motors, BMW and Volkswagen may be interested in the project. It also has not given a release date for the two new tires.

Tata Jaguar Land Rover to build first electric car

Tata Motors-owned Jaguar Land Rover (JLR) is set to build its first all-electric car in Austria. The luxury car-maker's Jaguar brand is expected to begin production next year. This car would be the latest in a string of launches after the new XE baby Jag and F-Pace sports utility vehicle.

The company is believed to be devising plans for a small production line in Austria, making about 10,000 cars a year. Jaguar wants to build an electric vehicle, in part, to sidestep looming European Union emission fines.

Tata Group had paid US\$ 2.3 billion in 2008 to buy JLR from Ford and has more than doubled its workforce to 32,000. The company now sells almost half-a-million cars, and is also planning to build a factory in America.

Finger-mounted device converts text to audio for the visually impaired

Researchers from MIT have developed a finger-worn device with a built-in camera that converts written text into audio for the visually impaired. The device provides feedback, tactile and audible, which guides the user's finger along a line of text, and the system generates the corresponding audio in real time.

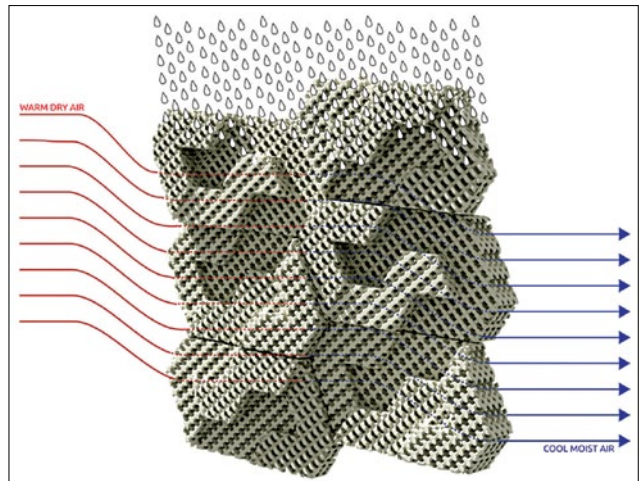
Roy Shilkrot, an MIT graduate in media arts and sciences, and his colleagues tested many variations of their device in a study with vision-impaired volunteers. One included two haptic motors, one on top of the finger and the other beneath it. The vibration of motors indicated whether the subject should raise or lower the tracking finger.

Another version, without motors, used audio feedback—a musical tone that increased in volume if the user's finger began to move away from the line of text. Researchers also tested the motors and the musical tone in conjunction.

However, they were unable to get consensus on which type of feedback was most useful. They are now concentrating on audio feedback, since it allows for a smaller, lighter-weight sensor. The key to the device's performance is an algorithm for processing the camera's video feed, which Shilkrot and his colleagues developed.

3D-printed brick that can cool your house

For centuries, people living in hot, dry places have harnessed the natural phenomenon of evaporating water to cool their homes, often through something called the Muscatese Evaporative system.



Cool Brick, the 3D-printed ceramic brick

In this low tech set-up, a wooden lattice covers the windows while a porous, water-filled ceramic jar sits inside it. As air passes through the lattice, water inside the jar evaporates, depositing a stream of cool air into the home.

The passive cooling system is inexpensive and energy-efficient and happens to be quite relevant today, as proven by 3D printing company, Emerging Objects.

The Oakland based company has translated the phenomenon of evaporative cooling into a 3D-printed ceramic brick named Cool Brick. This hand-sized piece of ceramic is essentially a hybrid of a wooden lattice and ceramic jar rolled into a single, lightweight slab.

According to its designers, the porous material can soak up water like a sponge; so when air passes through it, much like a wooden lattice, the water held in the micropores evaporates and introduces a cooling effect.

Faster paper-thin, flexi-screens for computers

The next generation of transistors may pave the way for flexible, paper-thin computer screens that provide faster response times and better efficiency.

Researchers at Japan's National Institute for Materials Science have reviewed the latest developments in research on photoactive organic field-effect transistors (OFETs)—devices that incorporate organic semiconductors, amplify weak electronic signals and either emit or receive light.

OFETs were developed to produce low-cost, large-area electronics such as printable flexible electronic devices. A lot of progress has been made in the development of light-emitting OFETs (LE-OFETs) since these first appeared in 2003. Research in this area has resulted in advances in the manufacture of novel organic photonics applications using cost-effective approaches.

Light emission efficiency and brightness of these transistors will improve, and further research may lead to the production of new display technologies.

LE-OFETs are also expected to become fully compatible with well-established electronic technologies. This may further allow the development of optical communication systems and opto-electronic systems.

LE-OFETs are being used to develop flexible, transparent computer screens, which are used to provide faster response times, better efficiency, and these do not need backlighting. These also have very low energy needs.

Light-receiving OFETs, on the other hand, are much less developed than their light-emitting counterparts.

Internet of Things sensors can run at lower power

As more sensors get added to the Internet of Things (IoT), power consumption may pose a problem. However, researchers at Massachusetts Institute of Technology, the USA, have come up with a solution to reduce the energy that such components require.

They have created a new circuit design that could lead to more power-efficient sensors, which are driving growth in the IOT segment. About 1.2 billion IoT-connected devices receive or transmit data wirelessly for alerts or analysis, and this number could grow to 5.4 billion by 2020, as per a study by Verizon.

Many sensors remain idle most of the time and become active when these send or receive data. Researchers have designed a circuit for a transmitter that could reduce energy leakage by up to 100 times when a sensor is in idle state. This could extend the battery life of sensors by months.

Wireless technologies are becoming more power-efficient but can still be one of the biggest electricity hogs in small devices. The new design does not compromise on wireless connectivity; it can generate enough power to transmit data using Bluetooth or 802.15.4 specification, which is the basis for Zigbee protocol.

The new circuit reduces transistor leakage by passing a negative charge through a set of capacitors and switches during idle time. The negative charge effectively banishes electrons from electrical leads, thereby reducing the conductivity of the silicon and also the opportunity for leakage.

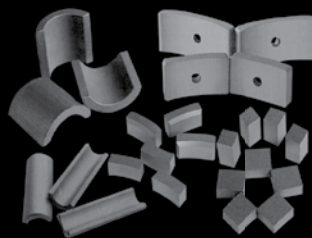
The team at Massachusetts Institute of Technology tested a chip based on the new design and found that it used only 20 picowatts of power to save 10,000 picowatts that would otherwise have been lost to leakage.

The research was led by Anantha Chandrakasan, professor of computer science at the institute. He has also researched technology that could self-power IoT devices by drawing energy from body heat, solar energy or ambient surroundings. The new transmitter design could complement the energy-harvesting technologies to make IoT devices more power-efficient.

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Tele-immersion: The Death of Distance



Deepak Halan is associate professor at School of Management Sciences, Apeejay Stya University

It is circa 2020, a tele-mentoring session is in progress, wherein a veteran surgeon in New Delhi is step-by-step guiding a less experienced surgeon thousands of kilometres away in London. Both surgeons share the view of the surgical field and control of the robotic system and can talk using microphones. Your brain tumor has to be removed via surgery immediately. However, no senior surgeon is available in the London branch of the hospital. Tele-immersion allows dissection without the need of the senior surgeon even touching the tumor. The operation is successful and your life is saved.

A few weeks later, you schedule a very important meeting with your business associates in Bengaluru. However, you have visitors coming in from New York to sign a mega business deal the same day. Without any stress, you go to a room called holodeck. There, inside a simulated environment, using information technology you contact your business associates. You are able to conduct the meeting with them almost as if you

are in Bengaluru. You even manage to shake hands with holographic images of your business associates. With a smile on your face you proceed to receive your guests from New York.

What is tele-immersion all about

Electronic visualisation laboratory (EVL), University of Illinois, defines tele-immersion as the union of networked virtual reality and video in the context of significant computing and data mining.

Tele-immersion is a technology to be implemented with the Internet2 that will enable users in different geographic locations to come together in a simulated holographic environment to interact. To users, it would appear as if they are actually interacting, communicating and meeting each other in person at a common location. In a tele-immersive environment, computers recognise the presence and movements of individuals as well as physical and virtual objects. These can then track living and non-living objects and project them in a realistic manner across many geographic locations. Holographic environments are

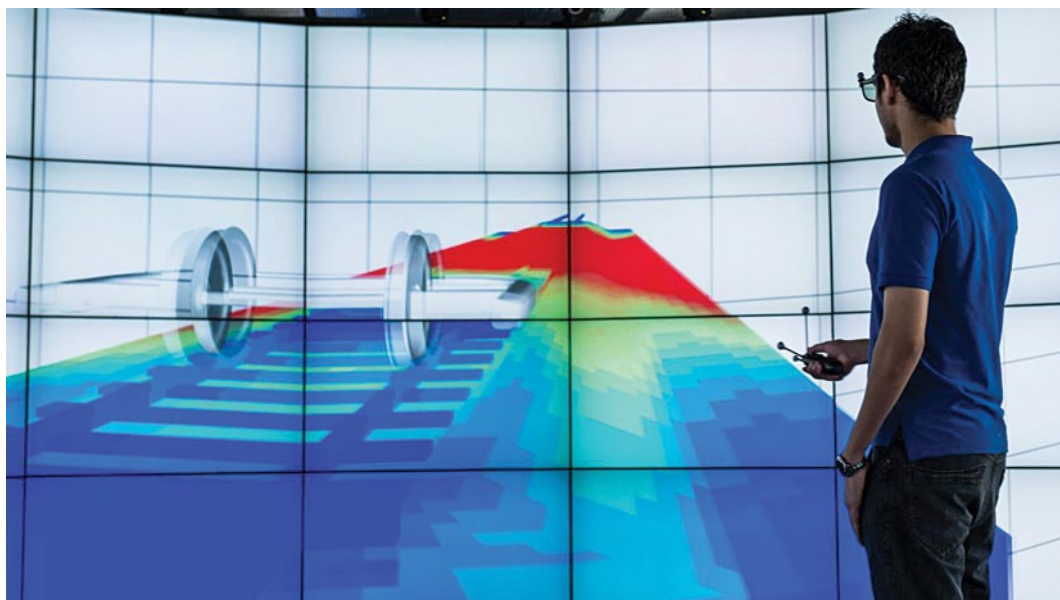


Fig. 1: Virtual train tracks as seen in EVL's CAVE2 (Source: www.evl.uic.edu)

generated by advanced computers that work at computing speeds thousands of times faster than PCs we use every day.

Three simple steps required to construct a holographic environment are:

1. The computer recognises the presence and movements of people and objects.
2. Then, it tracks those images.
3. Finally, it projects those images on a stereo-immersive surface.

The 3D reconstruction for tele-immersion is facilitated by projecting images on a stereo-immersive surface using IT. Two or more cameras take rapid sequential shots of the same object, continuously performing distance calculations and projecting those into the computer-simulated environment, to replicate real-time movement. By mixing cameras and the Internet telephony, videoconferencing allows real-time exchange of a vast amount of information effectively, without the need of the physical presence of every person in one central room.

The history

Ivan Sutherland, the great computer graphics pioneer, proposed the concept of Ultimate Display in 1965. It described a graphics display that allowed the user to experience a completely computer-rendered environment. In late 1960s, the ARPANET, conceived by the US Department of Defence, gradually evolved into the Internet. In 1998, Abilene, a backbone-research project was launched for the Internet2 research. The Internet2 needed an application that would challenge and stretch its networks capabilities. The head of Advanced Network and Services Inc. proposed tele-immersion as the application to drive forward the Internet2 research. Thus, the National Tele-immersion Initiative was formed.

The new broadband version of the Internet is capable of transmitting high volumes of data. Tele-immersion is the only application that can push



Fig. 2: A tele-immersive session in progress (Source: www.advanced.org/tele-immersion/news.html)

it to its boundaries. In May 2000, researchers at University of North Carolina (UNC), University of Pennsylvania and Advanced Networks and Services Inc. reached a milestone in developing this technology. A user sitting in an office at UNC in Chapel Hill, NC, was able to see life-like, 3D images of colleagues hundreds of kilometres away.

Elements of a holographic environment

Initial tele-immersive displays required users to put on unique goggles and a head device that tracked viewpoints of users looking at the screen. On the other end, people who appeared as 3D images were being tracked with an array of eight ordinary video cameras, while three other video cameras captured real light patterns projected in each room to calculate distances. This enabled proper depth to be recreated on the screen. Hence, if an observer moved his head to the left, he or she could see corresponding images that would be seen if he or she was actually in the room with the person on the screen.

Images on the screen were split and polarised to create a different image for each eye. The goggles then combined these images so that the brain recognised only one 3D image. This process was similar to how 3D movie glasses worked. Early experiments experienced some problems, often encountered during normal

videoconferencing. Scenes being projected were refreshed three times per second, which created an unsteady image. If that rate could be improved to ten frames per second, it would create a smooth projected image that would almost be like

looking at another person through a window. Scientists have been working on new technologies to support this type of communication. Here are some components and aspects of the new technologies:

Tele-cubicle. By means of which users communicate, a tele-cubicle consists of a stereo-immersive desk surface and two stereo-immersive wall surfaces (Fig. 2). These three display surfaces join to form a corner desk unit. Walls appear as windows to other users' environment, while desks join together to form a virtual conference table in the centre. This allows realistic inclusion of tele-immersion into the work environment as it consumes the average amount of desk space.

The Internet2. This will replace the current Internet infrastructure. It is a consortium made up of the USA government, industry and academia (over 180 universities) that was formed with the purpose of creating the Internet of the future. Good quality tele-immersion needs about 1.2Gbps. This new network will have a higher bandwidth and speeds 1000 times faster than today's Internet. This high bandwidth and speed network is necessary to transfer large amounts of data that tele-immersion will produce.

Display technologies. Stereo-immersive displays would have to present a clear view of the scenes being transmitted. Haptic sensors would allow people to touch pro-

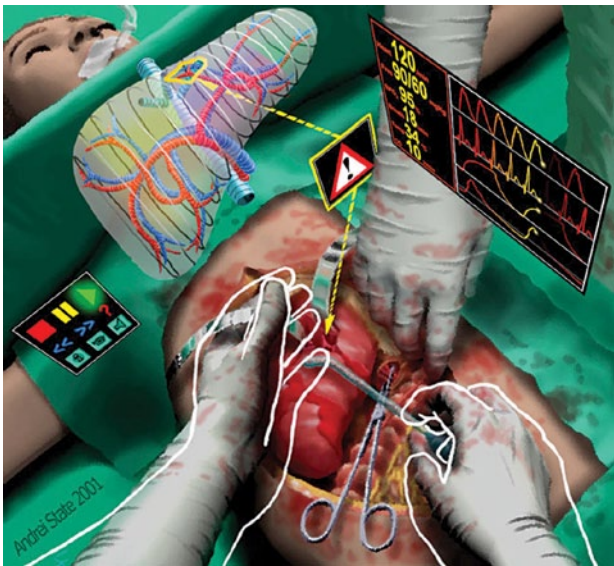


Fig. 3: Captured scene rendered from reconstructed 3D geometry mimicking the surgeon (Source: <http://graphics.cs.brown.edu/research/tele/teleImmersionApplications.html>)

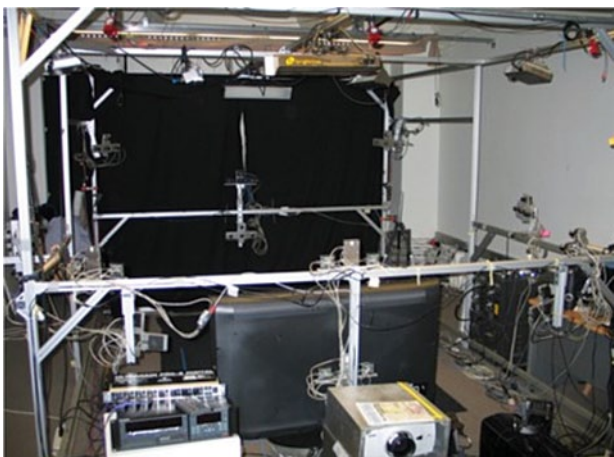


Fig. 4: The Tele-immersion Lab at University of California, Berkeley, the USA (Source: <http://tele-immersion.citris-uc.org/lab>)

jections as if these were real. And, desktop supercomputers would complete trillions of calculations needed to create a holographic environment. Another possibility to support these environments would be a network of computers that split the total power.

Application areas

Tele-immersion can benefit a host of areas from being able to meet relatives you are unable to visit to treating very remotely-located critical patients. Here are the main application areas:

In medicine. Tele-immersion can prove to be tremendously helpful

and even life-saving in the area of medicine. Traditionally, medicine has been taught and practiced face to face. However, with tele-immersion, 3D surgical learning for virtual operations is now possible. In times to come, we will be able to tele-immense a surgeon into an operation theatre to carry out a surgery (Fig. 3).

This could imply that many lives could be saved, especially if there are patients who are in dire need of a certain process or equipment that is not available at their location. Some loose ends that need to be tied are the legal implications in case of any system or tele-immersed surgeon failure. Also, since the doctor carrying out the operation is actually not physically present, how effective will he or

she be? Will the doctor be able to gauge what is transpiring in the back-end of medical services? Will the patient feel comfortable going through a critical procedure in this manner?

High-resolution 3D patient images have now become quite common, and it is vital to make this patient-specific data quickly available and usable to many specialists at various geographical locations. While web based systems can provide volume or surface rendering of medical data over networks with low fidelity, these are not able to manage stereoscopic visualisation or huge datasets effectively. This is where

state-of-the-art tele-immersion techniques and high-speed networks are required to produce an environment for geographically-distributed clinicians to share these huge datasets in real-time basis.

In education. Tele-immersion allows geographically-distributed students to come together in a single environment. This is particularly important given the lack of specialist faculty at all required sites, and hence the need to resort to distance education. This technology will result in a much higher level of collaboration among educational institutes. Moreover, it will also help in mitigating the risk, for example, budding surgeons will get a much better experience and training w.r.t. complex situations before actually operating on their first patients. In the similar manner, a pilot will experience an almost life-like flight simulation before his or her maiden flight. School students will be able to access data or govern a telescope from a remote location.

Research activities at the Tele-immersion Lab at University of California, Berkeley, the USA (Fig. 4), include human-robot co-operation, human activity recognition from multi-modal data, development of individualised musculo-skeletal models, quantification of human performance, remote monitoring in health care and its privacy and security considerations, and modelling of driver interaction in semi-autonomous vehicles. The lab supports research in 3D stereo reconstruction, tele-immersion, motion capturing, remote monitoring and human-movement analysis.

The tele-immersion apparatus with 48 cameras has been developed to capture 3D data of users with accuracy of about 1cm to 2cm. Cameras are linked to 12 servers that process the stereo reconstruction algorithm, allowing full-body 3D reconstruction of user(s). Some applications that the lab is presently concentrating on include collaborative work on 3D data sets, such as medical (MRI, 3D

X-ray), geo-scientific collaboration, collaborative design in CAD modeling, collaborative archaeology and remote teaching of physical activities/skills (such as in rehabilitation and dance performance).

In collaborative work. Tele-immersion will enable groups of engineers to work closely together across great distances on computerised designs, for say, developing innovative equipment (Fig. 5).

While different teams of engineers might be thousands of kilometres away, they would be able to work together on the same project as if they were sitting together on the same workbench.

Archaeologists from around the globe will have the same sort of experience during a critical excavation. Rarefied experts in building inspection or engine repair will be able to visit various sites without incurring time and money expenditure on air travel. Similarly, collaboration will be



Fig. 5: A collaborative design tele-immersion session in progress (Source: www.dvtelepresence.com)

possible while working on mechanical CAD. A team of designers will be able to work in partnership from remote sites in an interactive design process. They will be able to influence a virtual model, right from the conceptual to the production stage.

What the future holds

One of the current research areas is how to make tele-immersion more natural, perhaps by doing away with the headgear and glasses. Efforts are on for making the tele-immersion experience possible by simply entering a tele-cubicle. One solution is to use a screen that transmits diverse information to each eye, using swivelling

pixels that track either left or right eye.

Another probability is to turn the entire tele-immersion room onto a screen. Walls, chairs, roof, etc could be coated with special light-sensitive material.

A camera would photograph surfaces, computers would calculate their shapes in 3D and projectors would screen pre-warped images, making it appear as if these filled the room.

In years to come, perhaps one of your office walls will sparkle and your teammate will be sitting right in front of you, as if in person. On the other side, your teammate will enjoy the same experience. This possibility will make air travel quite rare. This is definitely going to have a favourable impact on our environment too with less greenhouse gas emission, which will make this planet a better place to live on. ●

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The Making of a Radio-Controlled Plane



T.K. Hareendran is an electronics hobbyist, freelance technical writer and circuit designer

If you are planning to make your own multi-rotor from scratch at home, note that choosing the right electronic speed control (ESC) for your radio-controlled electric aircraft (RC plane) is not an easy task. Although a number of interesting multi-rotor platforms, like monocopter, twincopter, tri-copter, quadcopter, hexacopter and octocopter, are available now, building one for fun flying/hovering completely depends on your imagination, skill and, of course, judicious selection and use of system components.

In any model aircraft, key components of the power system include an electric motor, electronic speed control and a battery pack. A perfectly-matched combination of the key components will bring out an efficient output from the power system. In fact, performance of the entire power system depends on the selection of the motor. Usually, brush-less motors (brush-less out-runner motors) are used in a power system.

Motor selection

There are a few vital considerations you should keep in mind when choosing the motor. The easiest choice is whether to use direct drive or a gear box, because if you are looking for high rpm (revolutions per minute), you will probably need a direct drive in-runner motor. For lower rpm, you can pick an out-runner in direct drive (or try an in-runner through a gearbox). In connection with this, always do your homework on other important things, like kV ratings ($kV = \text{rpm}/V$) of the motor, battery voltage and capacity of the battery pack, among

others. Some important specifications that come with brush-less motors are kV, max. current (A), shaft diameter, thrust, suggested propeller, lithium polymer (LiPo) (3S-4S) and weight.

With a known kV rating, you can calculate the rpm of the motor using the formula $\text{rpm} = kV \times V$, where V is battery voltage. The maximum current rating indication helps you pick the right ESC and battery pack. Similarly, the shaft diameter helps you select the right propeller. Thrust is the value of the force that the motor can produce with the suggested propeller. LiPo (3S-4S) indicates the motor's ability to run on 3-series (3S = 11.1V) and/or 4-series (4S = 14.8V) LiPo battery packs.

Rough calculation. If you are making a quadcopter for lifting 1000gm of payload, 2000gm thrust is a common requirement*. Since a quadcopter has four motors, each motor should handle at least 500gm of thrust to function better.

(*The basic formula you should keep in mind is that, AUW (all up weight) of a multi-rotor should be half of the total thrust, that is, total thrust (minimum) = $2 \times \text{AUW}$.)

Electronic speed control

For the ESC to work with your selected motor, it must be rated for voltage of your LiPo battery pack, and it must be able to handle the motor's voltage and current requirements. In principle, it is always better to have an ESC with a rating slightly higher (1.5x maximum) than the peak current (at full throttle) requirement of the motor.

All ESCs have inherent voltage and current limitations. So, select an ESC that is designed to work with an equal or higher voltage. It is not recommended to connect a high-voltage battery to a low-voltage ESC, and a high-voltage ESC to a low-voltage battery. Likewise, it is very important to know the peak current rate of the motor at full throttle. Always prefer an ESC with a current rating that is higher than the actual demand.

Brush-less out-runner motors



ESC provides varying electric power from the battery pack, according to the input signal. Most ESCs also have a battery eliminated circuit, which is nothing but a 5V DC output that can power-up the electronics, including the receiver, servo motor and flight controller.

Another feature available in many ESCs is low-voltage cut-off (LVC) circuitry. This protects the LiPo battery pack from being discharged too much, to save it from being permanently damaged. We can fine-tune most ESCs with exotic throttle profiles (throttle range, battery mode, etc), with the help of computer based configuration programs.

Rough calculation. If the maximum current rating of the motor is 10A, then the capacity of the ESC should be $10 \times 1.5 = 15A$ and $I_{(ESC)} = I_{max} (motor) \times 1.5$

The propeller size strongly influences the electric current flow through a system. A large propeller will draw higher current from the battery through the ESC and make the system run hot. Since every motor, ESC and battery operates at a specific maximum allowable current, exceeding the limits could soon burn-out the motor, ESC or battery pack.

Battery pack

Compared to NiMH and NiCd battery packs, LiPo battery packs are ideal for use with brush-less motors in radio-controlled airplanes and copters due to their small profile, low weight and high capacity. When looking for a battery pack, keep an eye on the maximum current rating of the motor(s) used, at first.

Some important specifications of a battery pack are mAh, C and 1S/2S/3S/4S.

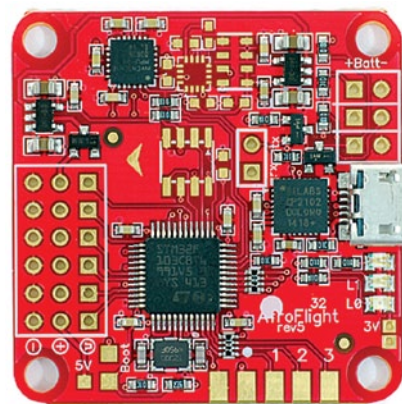
mAh rating indicates the capacity of the battery pack (more mAh gives more flight time). C is the discharge rate, that is, an indicator of the maximum current (A) level at which a battery can be discharged at a particular time period. 1S/2S/3S/4S reveals the inside combination of the LiPo battery



Electronic speed controls



LiPo battery pack



Flight controller

pack. 1S means one cell of 3.7V, while 4S means four cells of 3.7V (14.8V). Just multiply C rating with the battery pack's capacity (mAh) to determine how many amperes can safely be pulled from the battery pack. For example, an 800mAh battery with 10C rating can continuously provide an output of 8A ($0.8 \times 10 = 8$).

Quick tip. For a longer flight time, it is better to use a battery with higher mAh capacity at the same C rating, or a battery with higher C rating at the same mAh capacity. For example, an 800mAh 20C battery is better than 1500mAh 10C battery, because $800mAh \times 20C = 16A$ and $1500mAh \times 10C = 15A$.

Flight controller (FC)

Literally, a flight controller overlooks the operation of the flying machine,

including reading RC radio inputs, controlling motors and determining the orientation.

RC radios have multiple signal outputs, one for each channel/stick/switch/knob. Each radio output transmits a pulse (usually at 50Hz), with the width of the pulse determining where the stick is on the RC transmitter (for example, 1000µS for throttle 0).

As stated, motors are controlled with the ESC. It is always necessary to determine which orientation, or attitude, the flying machine is in for, for varying the motor speed along with the pilot's commands. In practice, two sensors are commonly used for determining orientation—accelerometer and gyroscope. An accelerometer measures acceleration in each direction and a gyroscope measures the angular velocity.

DIYers, think first

Building your own ESC for brushed/brush-less motors is not a very difficult task if you have enough knowledge, skill and patience. There are a number of tried and tested designs that have been published for ESCs. However, reliability of a home-made ESC may raise an important safety issue because a DIY ESC is probably going to be heavier than an SMT based modern commercial ESC. Under certain circumstances, you can save money by building your own ESC, but most of the time there is not much cost advantage to it.

Important challenges in designing an ESC are:

1. Accurate timing of the throttle control pulse
2. Accurate pulse width modulation (PWM) generation to ensure the motor speed is even, and the motor does not make unacceptable noise and harmful vibrations
3. Integration of optional features, like lost model alarm (LMA) and glitch counter
4. Maximising power efficiency

Warning! Model aircraft is not a toy. Please construct, test and use RC flying models at your own risk. ●

Your Phone, Your Network, Your Apps: Everything Would Change by 2020



Janani Gopalakrishnan Vikram is a technically-qualified freelance writer, editor and hands-on mom based in Chennai

Even as buyers wonder whether to buy a 3G phone or a 4G one, even as developers discuss which platform to develop their apps for, even as wearable makers and media houses harness the boons of 4G, elsewhere in the world, researchers are moving ahead.

Major telcos and device makers are betting on the arrival of 5G by 2018, or at the most by 2020. This would mean more than just buying another instrument and changing your data plan. Trend watchers and industry experts believe that this will change everything in the telecom value chain. The network infrastructure would change; bandwidth would be unimaginably high. Millions of users would be able to send across large data packets, say, a movie would transfer before you can say zap! This would mean many changes in mobile devices—not just in terms of wireless technology, but everything from battery and storage to camera and display, because with better connectivity people would want to do much more with their phones. As people do more with their phones, more data would get generated; so data centres would be impacted too. Homes and cities would get smarter. More signals would fly across the air, and perhaps more birds would die—unless technologists come up with a solution for that too.

Here, in this feature, we take a look at some ways in which global telecommunications is bound to change in the next couple of years. Would you be able to recognise the phone in your pocket? Would you buy CDs anymore? Would you pay a smaller or larger mobile bill? Read on to find out.

A network that understands the user's needs

The 5G network will provide speeds that you cannot even imagine today. Prof. Rahim Tafazolli, director of 5G Innovation Centre (5GIC) at University of Surrey, said in a recent BBC News story that it would be possible to run wireless data connections at 800Gbps with 5G, which would, according to him, be a dramatic overhaul and harmonisation of the radio spectrum.

5G will be like the Internet. 5GIC likens the 5G network to the Internet in its ability to adapt, evolve and grow. It will not be a frigid network that chokes and splutters under pressure from smarthomes, cars and cities! Despite a constant increase in the number of connected devices, it will attempt to enable real-time responses for all.

Logically unlimited data rates. While such limitless bandwidth is not physically possible, it can be done logically; that is the innovation in 5G. The upcom-



5G Innovation Centre at the University of Surrey (Courtesy: University of Surrey)

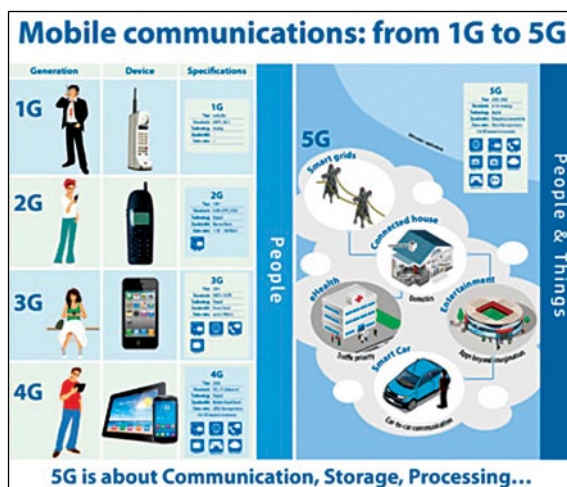
ing telecom era would give each user the satisfaction of getting seemingly unlimited data rates, while resources would be juggled and shared in the background. This would be achieved by predicting user demand, encouraging apps to perform bandwidth-intensive tasks during non-peak time, optimising network response times based on latency and making better use of available wireless networks.

Virtualisation at work. We are likely to see network virtualisation and cloud-like concepts implemented on the radio network. 5G is likely to use cognitive radio technology to enable different radio technologies to share the same spectrum. Base stations would be classified into radio units and baseband units, so that baseband units can be pooled to handle a high number of radio units. Optimisation of radio resource management (RRM) techniques is one of the key research areas of 5G.

Likewise, there will be a clear split between control and user planes, to facilitate heterogeneous network deployments. All user devices can be controlled on a macro layer, while user data is independently provided through a femto cell.

Smartantennae. Technologies like massive multiple-input-multiple-output (MIMO) and beam-forming active antennae will be at the heart of 5G. Smartantennae will help alter beam direction, enabling more direct communication. This would increase overall cell capacity, reduce interference and compensate for path loss with higher antenna gains. Such adaptive beam-forming algorithms are likely to be implemented on all user devices.

Versatile and responsible terminals. 5G, being a user-centric rather than operator-centric network, will shift the onus to the terminals to provide the best experience. 5G terminals are likely to have modulation schemes, error-control schemes and software-defined radios that can be downloaded from the Internet. These terminals will be able to access, choose and combine different wireless technologies and ser-



Evolution of mobile communications
(Courtesy: European Commission)

vices from different mobile/wireless access network providers.

Apart from these, research is also on to reduce battery consumption of network devices (increasing their life on the scale of months or years, rather than days or weeks), optimising deployment and operating costs, and so on.

User-centric business models

Given that 5G is disruptively different from its predecessors, many new and user-centric business models are expected to arise out of it.

User can give and take. A recent report by The Telegraph, the UK, predicts that by 2020, each person will have an average of 27 devices. These devices might be in their cars, homes, offices or bags. But just imagine having to pay for the data transacted wirelessly by all these devices? Fortunately, this scenario of service providers and users playing a clear supply and consumption role is likely to change. Like in the case of a smart power grid, where users can sell excess energy from alternative sources to the power utility, 5G—likely to be the grandfather of all networks—will allow users to make money by charging others for the coverage they provide with Wi-Fi routers or femto-cell home base stations.

No more tech pushing. The user is expected to shape the very funda-

mentals of the 5G business. Rather than being just another telecom generation, where operators push a new technology to users, it is believed that 5G will be a network that evolves to meet the demands of users from totally new markets.

Linda K. Moore, a specialist in telecommunications policy at the Congressional Research Service, writes in a recent report that, 5G might be shaped not by carriers pushing new technology

but by demand from new customers, customers that are the mainstay of important industrial sectors other than telecommunications. These include transportation, agriculture, energy, mining, defence and public safety, entertainment, medicine and finance, to cite some examples where new technologies are influencing whole industries. These industries might prefer not to manage important parts of their businesses based on somebody else's business model and may demand new techniques and service providers.

Information reselling. Since much more data is going to be generated by all our devices and apps in the 5G era, a whole industry is going to revolve around managing, mining and monetising this Big Data, albeit with privacy regulations in place.

User focus being a rather new paradigm in telecom networks, several consortiums are being formed around the world to understand the true 5G and the business models it is likely to give birth to.

All-new apps

What would you do with a mountain of money? Well, that is how you would feel when granted a seemingly unlimited data rate network connection, right? Add to this the fact that 5G is expected to have an extremely low latency, which means you would get responses instantaneously with

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delays imperceptible to the human brain. Naturally, apps would evolve amazingly.

Videos would be captured and transmitted on-the-go. Movies would be downloaded in seconds. You would be able to watch all your favourite television programmes on the phone itself. Social media would morph into a more exciting *avatar*, and so on. In a 2014 story by The Telegraph, the UK, experts predict that videos will represent 79 per cent of the data passing over the network by 2030. Standard-definition videos will disappear, and high-definition will become the norm, as 4K and 8K videos become more widespread. The download speed for a video stream is going to reach about 18Mbps, while the upload speed will also become increasingly important due to the popularity of apps like Instagram and iCloud. Sixty eight per cent of non-video demand will be made up by either augmented reality or mobile gaming.

That said, the real impact of 5G might be felt not just in entertainment and social apps, but also in businesses and other sectors like healthcare and automotive. Road-safety apps, for example, would become highly reliable as 5G would enable real-time, low-latency car-to-car communications. So, you would be getting instantaneous reports on the traffic situation and be alerted if a driver in front of you swerves suddenly.

Likewise, remote surgeries would improve with low-latency networks like 5G, because the doctor's reactions to the patient's condition would be captured immediately, just like in a real surgery.

The phone in your pocket

If the network is going to change, and also the apps, then the phone has to, obviously, change.

Wow, what clarity. If you are going to thrive on videos, surely you would need a better display on your mobile device. Several innovations, which seem cutting-edge today, such as automatic brightness adjustment,

extremely high resolutions, smooth transition from one environment to another and correction of defective vision, could become mainstream in the phones of 2020.

Capture it live. Problems like slow zoom-in, late focus and bad image quality in poor lighting conditions will not be acceptable to next-gen users. Going by the research happening around the world, we are likely to get smartphone cameras that will behave almost like our eyes, capable of focusing in real-time, tracking objects and automatically adjusting to the environmental lighting.

Less charging, more working. As mobile devices become such an integral part of our lives, we need to start worrying about not just data costs, but also power. Fortunately, researchers are working on super battery technologies, which will enable devices to work for longer with shorter charges. A team at Stanford University announced last year that they had designed a way of increasing the capacity of existing battery technology by 400 per cent.

Likewise, battery packs and power bank companies are innovating to provide a full charge to batteries within a few minutes, rather than taking almost an hour. If the trend continues, we should be able to run the dream phone of 2020 for a week or more with a few minutes' charge.

Supercomputing phones. Good network, great camera, super display—nothing would help if the processor is not up to it. I guess we need not worry on that front, with the low-power processor industry heating up with competition. If AT&T's 2012 report is to be believed, we are sure to have a supercomputing phone in our hands by 2020!

So, whether South Korea wins the race by trialling 5G at the 2018 Winter Olympic Games or Japan keeps its promise of launching a 5G trial network for the Summer Olympic Games in 2020 in Tokyo, one thing is for sure—there is a lot of excitement in store for us in the days to come. ●

5G Technology to Benefit Cyber Physical Systems



Anagha P. is a technical correspondent at EFY

According to a press release by Telecom Regulatory Authority of India (TRAI), the number of mobile phone subscribers in the country has crossed 952.34 million, as of January 2015, and is continuously growing. The Ericsson mobility report from November 2014 also predicts that 45 per cent of Indian telecom subscribers will be covered by fourth-generation (4G) long term evolution (LTE) by the year 2020.

With the introduction of affordable and 4G-supported devices like Xiaomi Redmi Note, Elephone P3000, Lenovo A6000 and Gionee P6, 4G technology has already become accessible to the common man. Where will 4G go next, and what exactly is 5G?

Advances in voice over LTE

Modern-day phones perform a lot more than the traditional function of voice communication. These features were enabled in 2G and 3G networks through voice over Internet protocol (VoIP). Though it has a wide user base and is utilised by popular apps like WhatsApp, Skype and Google Hangouts, the quality of service components is not the best. Packets of data are sent over the Inter-

net and a portion of these packets is often dropped under stress. This is where voice over LTE (VoLTE) comes into play.

Being service-driven, VoLTE works with 4G LTE network and uses IP multimedia subsystem (IMS) and radio access network (RAN) features. The IMS layer offers low latency, error correction and several features for better quality of service. VoLTE service currently available in India has to improve considerably, points out Srinivasa Moorthy, director of design engineering, D4X Technologies Pvt Ltd. Packets sent using VoLTE sometimes do not suffer the same delay in a sequence. The network should be capable of minimising this delay and autocorrecting it.

Small cells deployment

Vodafone and advertising firm JCDecaux signed an agreement for a global small cell rollout a few months back. You may ask, what does an advertising firm have to do with mobile network technology? Under the deal, small cells will be placed in street furniture and billboards to improve network performance in congested urban areas. Talk about creative solutions!

Small cells basically take mobile signals transmitted by macrocells and direct these to mobile transceiver units within a range of 10 to several hundred metres, and vice versa. These have gained much importance in LTE era and are usually deployed both outdoors and indoors, where signals are weak or networks are overloaded. These areas include rural regions, basements and parking areas of buildings, home and office spaces.

Unlike a macrocell, a small cell occupies only a small space, emits clean and environment-friendly signals, does not require mobile tower leasing cost and significantly expands the network coverage at any place.

Since these are installed at lower heights, the distance between user terminals



and the access node reduces. This accounts for better transmission quality and performance, reduced delay and better coverage especially at cell edge. It also provides a great business solution as the user gets flexible and quality services at a reduced cost.

In late 2014, the second edition of the annual Small Cells India 2014 event took place in Mumbai, where players like Huawei, Aricent, iBwave and members of Cellular Operators Association of India (COAI) came together to understand how to cost-effectively optimise small cell networks in India.

How is 5G shaping up

The fifth generation of mobile communication is already in its development phase around the world. Any new telecommunication technology including 5G (excluding standalones like Bluetooth, Zigbee or Wi-Fi) will be very similar to LTE, foresees Nagaraja Upadhyaya, vice president of network product line, Huawei Technologies Co. Ltd. Although the industry's estimated year of commercial introduction of 5G is 2020, Huawei has already collaborated with Mega-

When will we see 5G

Historically, successive generations of mobile technology came out every 10 years. 1G was introduced in 1981, followed by the second-generation rollout in 1991. The first 3G system showed its head in 2001 and 4G systems compliant with international mobile telecommunications-Advanced (IMT-Advanced) were standardised in 2012. We can speculate that 5G will be ready for primetime in 2021. Right now, teams worldwide are working on the concept.

4G standardised in 2012; how have we not seen it yet

There are several factors that contributed towards the success of 4G telecommunication technology around the world. Better speed, voice and video clarity, buffer and bus efficiency, battery life and security, speedy adoption of smartphones by customers and replacement of landlines, and reduced latency are some of the major factors that drove this movement. This also positively affected the business sector.

But in India, 3G and 4G have not reached their prime yet. Several rural and some urban areas still rely on 2G and previous technologies for mobile communication. The high cost and complicated procedures for buying the spectrum results in operators having very less time and money to invest on infrastructure development and deployment of new technologies.

Fon, and is targeting demonstration of this technology during FIFA World Cup 2018. 5G would be expensive and more beneficial for the business sector, rather than the end consumer, predicts Moorthy.

Apart from having better speed, this technology is going to focus on having low latency (of a few milliseconds), high quality of data transfer, better bandwidth and network capacity (number of connections that can be implemented). These features are

an asset to business models for cyber physical systems or the Internet of Things (IoT) and machine-to-machine (M2M) communication.

Next Generation Mobile Networks (NGMN) expects customer requirements of 5G in the 2020 + timeframe to result in the accommodation of massive traffic growth and high-density demand, a wide variety and variability of services consumed, new use cases such as machine-type communication (M2M and the IoT) and stringent demands for real-time communications.

NGMN has finalised and plans to announce the publication of its 5G white paper at the NGMN industry conference and exhibition, scheduled for March 24-25, 2015, in Frankfurt, Germany. Board of directors, senior industry and research representatives as well as subject matter experts plan to discuss all related technology and eco-system aspects. The conference might provide a good overview on 5G requirements, its technology evolution, architecture principles, future services, spectrum demand and intellectual property rights policy.

Technological hiccups

Since many mobile phone users in India still use GSM and 2G technology, it will take a while to adopt 4G and 5G; an overlap period of these technologies is expected to be high. This

Who on Earth uses WiMAX

Worldwide interoperability for microwave access, popularly known as WiMAX, is a communication standard that descends from W-Fi technology. WiMAX was created by WiMAX forum in early 2000s, even before the advent of LTE. WiMAX is similar to LTE in that these both claim to belong to the fourth generation and support multiple-input and multiple-output (MIMO) antenna technology and orthogonal frequency division multiplexing (OFDM) modulation technology.

But it failed to take off like the latter due to several reasons that include:

- LTE is a natural technology evolution of previously used mobile technologies. It is compatible to, and provides easy migration path from standards like GSM, GPRS, UMTS, EDGE, WCDMA, HSPA, CDMA-one, CDMA2000, EV-DO, EV-DV and SC-CDMA for operators, and components and device manufacturers. The smooth transition from 3G to 4G also leads to a better user experience. In addition to this, LTE also supports roaming services better than WiMAX.

- LTE is backed by 3rd generation partnership project (3GPP), one of the strongest organisations for mobile telecommunication. "3GPP forum is very well accepted among telecom components and chips manufacturers, handset vendors, test and measurement companies, and infrastructure developers," says Jayanth Ramachandran.

- Performance of LTE is also found to be better than that of WiMAX. It handles speed of about 450kmph, while WiMAX can go only to about 120kmph. The former offers better mobility to customers.

- "Managing networks becomes easier with LTE," says Moorthy. "It provides an end-to-end IP network solution," he adds.

But the cost of deployment for WiMAX networks is much lesser as compared to LTE networks. According to Upadhyaya, "WiMAX is the best choice for private mobile broadband wireless networks where cost is a major concern".

is why a rollout plan having flexible hardware with backward compatibility to legacy technologies is a prime requirement for the implementation of new wireless standards. "This calls for devices and infrastructure equipment supporting multi-technology with flexible plugins of hardware and software modules," says Jayanth Ramachandran, business development head - telecom, Rohde & Schwarz India.

The software and hardware should be smart, proactive and reduce CPU usage of a device. Custom-developed application-specific integrated circuits (ASICs) are being used to solve these challenges. The platform also needs to support both frequency division duplexing (FDD) and time division duplexing (TDD) modes, depending on the spectrum used. "In the case of software, upgrades should be possible without stopping the device," comments Nagaraja.

The hardware approved for a foreign country may not work in India due to the environmental conditions here. Any generic technology is to be customised for matching the Indian scenario, and there should be a well-defined set of standards for testing and manufacturing of the same. Field testing of telecom equipment, which includes interoperability development testing (IODT) and interoperability testing (IOT), are necessary before bringing any product to the market. But, due to prevailing uncertainties related to frequency bands, test and measurement firms will have to support a wide range of bands and antennae schemes.

"However, one of the biggest concerns for implementing 5G technology would be the uncertainty of the propagation model at higher frequency bands, which are being planned to be used," comments Jayanth. Different regions of the spectrum are suited for different applications. Ravi Manik, director of business development at Broadcom adds, "The end user experience depends on what kind of bandwidth is available."

Two distinct themes for 5G

1. A super-fast mobile network comprising next-generation small cells, densely clustered together to give a contiguous coverage over at least urban areas and delivering peak data rates of up to 1Gbps. It gets the world to the final frontier for true wide area mobility. Spectrum for this would be under 4GHz (in order to make wide area coverage economically feasible). Since nobody is likely to reserve spectrum for 5G, such a network would enter the market through advanced spectrum sharing. Hence, in this vision 5G might be the first global implementation of dynamic spectrum access. The band 3.4GHz - 3.6GHz has been talked about for such a spectrum sharing market entry for 5G.

2. A converged wireless fibre network that uses, for the first time for wireless Internet access, millimetre wave bands (20GHz - 60 GHz) so as to allow very wide bandwidth radio channels to be able to support data access speeds of up to 10Gbps. The connection essentially comprises short wireless links at the end of the local fibre optic cable. It takes data over wireless to state-of-the-art level. But this very high data speed comes at a price for consumers in terms of very much reduced coverage. It would be more of a nomadic service (like Wi-Fi) to fixed locations rather than a wide area mobile service.

—*Courtesy: GSMHistory.com*

MAJOR CONTRIBUTORS TO THIS REPORT



Jayanth Ramachandran,
business development head
- telecom, Rohde & Schwarz
India Pvt Ltd



Nagaraja Upadhyaya,
VP of network product
line, Huawei Technologies
Co. Ltd



Ravi Manik,
director of business
development, Broadcom
India and South East Asia



Srinivasa Moorthy,
director of design
engineering, D4X
Technologies Pvt Ltd

Defence sector occupies a key portion of spectrum in India, and firms feel that they need to be funded by the government to vacate and release additional (unused) spectrum for the development of the commercial telecom sector in our country.

Alternate bands. Commercialisation of television white spaces can decongest the existing 3G and existing 4G networks. With superior wireless radio propagation characteristics, these can also lead to better mobile coverage in rural areas. Designers are also looking into millimetre wave and microwave technologies to solve the challenges of backhaul connectivity in mobile networks, according to Manik.

What are white spaces

White spaces refer to the unlicensed frequencies in the spectrum allocated to broadcasting services. With television broadcast moving from analogue to digital, a lot of frequency bands get freed up; these unused frequen-

cies are known as television white spaces. The average white space in the ultra high frequency (UHF) television band in India is above 100MHz (as per quantitative assessment of television white space in India by Gaurang Naik, Sudesh Singhal, Animesh Kumar and Abhay Karandikar, IIT Bombay.) This technology is still in its innovation stage and several prototypes for power over Ethernet (PoE) system using this method are being tried out.

Better-connected future

With the ever-rising number of smart-devices and an increasing demand for better quality of service, telecommunication and related technologies are being researched and remodelled continuously. While work is being carried out to improve existing systems and make these accessible to the general public, there is no doubt that 5G is going to be the next big thing in communication and can be expected to reach the market in another five years. ●

IMT: Advanced Requirements and 4G Candidate Technologies



Dr Rajiv Kumar Singh holds a Ph.D. in electronics engineering from IIT (BHU), Varanasi, and is currently employed with Lovely Professional University as assistant professor. Previously, he was associated with BSNL. He received senior research fellowship of UGC at Centre of Advanced Study at IIT

With the objective to fulfil the 4G criteria of 1Gbps for stationary reception and 100Mbps for mobile reception, many wireless technologies are rapidly progressing to meet and surpass 4G requirements.

4G is the fourth generation of mobile wireless standards—a successor to the 3G and 2G families of standards—and is expected to provide a comprehensive and secure all-IP based mobile broadband solution to laptop/computer wireless modems, smartphones and other mobile devices. With the help of such promising next-generation technology, facilities such as ultra-broadband Internet access, IP telephony, gaming services, high-resolution streamed multimedia [multimedia messaging service, video chat, video conferencing, mobile TV and HDTV (high-definition TV)] may be provided to users. The system will allow global roaming, higher rate of data transfer with much higher and tight security and safety features, all at a lower cost.

In 2009, the International Telecommunication Union—Radiocommunication

(ITU-R) group specified the international mobile telecommunications-Advanced (IMT-Advanced) requirements for 4G standards, setting peak speed requirements for 4G services at 100Mbps for high-mobility communication and 1Gbps for low-mobility or fixed communication. As the most advanced technologies currently defined for global wireless mobile broadband communications, IMT-Advanced is considered as 4G, although it is recognised that this term may also be applied to the forerunners and other evolved 3G technologies providing a substantial level of improvement in performance and capabilities with respect to initial third-generation systems.

IMT-Advanced or 4G systems are mobile systems that include new capabilities of IMT that go beyond those of IMT-2000. Such systems provide access to a wide range of telecommunication services including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet based. IMT-Advanced systems support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments. Moreover, IMT-Advanced has capabilities for high-quality multimedia applications within a wide range of services and platforms, providing a significant improvement in performance and quality of service. These features enable IMT-Advanced to address evolving user needs.

Scanning the mobile generations

There are no specific measures to consider the years of generations. Rather, generations are measured on the basis of significant stages or considerable innovations in standards and applications.



Significant stages in the evolution of mobile radio systems are referred to in terms of generations: 0th generation or 0G, first generation or 1G, second generation or 2G, third generation or 3G, and fourth generation or 4G. Reviewing previous wireless generations will help put 4G in context.

0G systems preceded modern mobile telephony and are referred to as mobile radio telephone systems. Mobile radio service originated with Bell Systems in 1946. Technologies used in pre-mobile systems included push-to-talk (PTT or manual), mobile telephone system (MTS), mobile telephony system A/B/C/D (MTA/B/C/D), *offentlig landmobil telefoni* (OLT), improved mobile telephone service (IMTS) and advanced mobile telephone system (AMTS).

The 1G of mobile generation came in 1980s, offering for the first time a relatively affordable mobile wireless telephony service. 1G was characterised by a multiplicity of incompatible regional analogue standards such as analogue advanced mobile phone system (AMPS)—North American standard in mobile band (800MHz), total access communications system (TACS)—the UK-originated standard based on AMPS in 900MHz band, Nordic mobile telephony system (NMT)—Scandinavian standard in 450MHz and 900MHz bands, C-450—German standard in 450MHz band and Japanese total access communications system (JTACS)—Japanese standard in 900MHz band. These incompatible analogue standards kept the market fragmented, expensive and without national roaming facility.

In early 1990s, global system for mobile (GSM) communication, the first of the digital 2G, arrived to provide telephony plus text messaging and limited circuit-switched data services. For GSM, everything lined up—technology, demand, supply, pricing, value and delivery costs. The result remains an enormous international industry that in 15 years

IMT-Advanced Requirements			
Criterion	Test environment		Threshold
Cell spectral efficiency (bit/s/Hz/cell) [The aggregate throughput of all users (the number of correctly received bits over a certain period of time) divided by channel bandwidth divided by the number of cells.]	Indoor	Downlink	3.0
		Uplink	2.25
	Micro-cellular	Downlink	2.6
		Uplink	1.8
	Urban coverage	Downlink	2.2
		Uplink	1.4
	High speed	Downlink	1.1
		Uplink	0.7
Peak spectral efficiency (bit/s/Hz) (Highest theoretical data rate)		Downlink	15.0
		Uplink	6.75
Bandwidth (MHz) (Candidate technologies are supposed to support a scalable bandwidth upto 40MHz and are encouraged to operate upto 100MHz.)			40
Cell edge user spectral efficiency (bit/s/Hz) [Five per cent point of cumulative distribution function (CDF) of the normalised user throughput.]	Indoor	Downlink	0.1
		Uplink	0.07
	Micro-cellular	Downlink	0.075
		Uplink	0.05
	Urban coverage	Downlink	0.06
		Uplink	0.03
	High speed	Downlink	0.04
		Uplink	0.015
Latency (ms) (Transition from different connection modes, for example, from idle to active state.)	Control plane		<100
	User plane		<10
Mobility (bit/s/Hz)	Indoor	@10km/h	1.0
	Micro-cellular	@30km/h	0.75
	Urban coverage	@120km/h	0.55
	High speed	@350km/h	0.25
Handover (HO) (The handover interruption time is defined as the time duration during which a user terminal cannot exchange user plane packets with any base station.)	Intra-frequency HO interruption (ms)		27.5
	Inter-frequency HO interruption within a band (ms)		40
	Inter-frequency HO interruption between bands (ms)		60
Voice-over IP capacity (active/users/sector/MHz)	Indoor		50
	Micro-cellular		40
	Urban coverage		40
	High speed		30

grew from nothing to being owned by more than half the people on the planet, revolutionising the way the world communicates.

2.5G, which stands for second and a half generation, is a mobile wireless technology developed in between its predecessor, 2G, and its successor, 3G. 2.5G is used to describe 2G systems that have implemented a packet-switched domain in addition to circuit-switched domain. Such a packet-switched base service

is general packet radio service (GPRS) that can provide moderate-speed data rates from 56kbps to 114kbps using time division multiple access (TDMA) channels in the GSM system.

Another extension of GSM is 2.75G—enhanced data rates for GSM evolution (EDGE) or IMT-SC (single carrier) that is able to support both circuit-switched and packet-switched networks. EDGE can carry a bandwidth up to 236.8kbps for four timeslots (theoretical maximum

is 473.6kbps for eight timeslots) in packet mode. The other main 2G system is code division multiple access (CDMA), which offers services similar to GSM but in different geographies.

Following the phenomenal and unexpected success of 2G, there was heightened anticipation of what 3G would bring, but 3G's contribution to date is a very mixed bag. On a technical level, 3G met the increased single-user data rates mandated by IMT-2000 requirements, but the uptake of much-hyped 3G services such as video telephony has been poor. This is why 3G subscriptions are just over seven per cent of 2G subscriptions, and many of these are primarily using telephony and basic messaging rather than 3G-specific data services.

Real uptake of data services did not start until the introduction of the so-called 3.5G packet based data services, like high-speed downlink packet access (HSDPA) on universal mobile telecommunication system (UMTS) and evolution data optimised (1xEV-DO) on CDMA2000. Dedicated data-only devices with flat-rate tariffs (for example, USB dongles used with laptops) are showing strong growth in some markets with good performance, at least for early adopters. 3G's impact is currently much less significant than the step from 1G to 2G.

Pre-4G technologies, such as mobile worldwide inter-operability for microwave access (WiMAX) and first-release 3G long-term evolution (LTE), have been available in the market since 2006 and 2009, respectively. Early WiMAX versions and first-release LTE captured the attention of wireless service provider giants around the world, but their market penetration is yet to be seen and their fate is not very clear.

4G refers to the fourth generation of mobile wireless standards. It is a successor to 3G and 2G families of standards. The expectation for 4G technology is basically the high-

quality audio/video streaming over end-to-end Internet protocol.

IMT-Advanced requirements

ITU-R for IMT-Advanced has set a specific level of minimum performance that each proposed technology needs to achieve to fulfill the objectives of IMT-Advanced. These requirements are demonstrated, at a glance, in Table I.

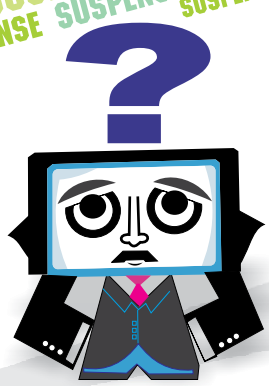
IMT-Advanced (4G) candidate technologies

Based on the thresholds set by ITU-R for IMT-Advanced, none of the wireless technologies at present, including LTE, high-speed packet access + (HSPA+) and WiMAX can be considered as 4G technology.

For HSPA+, main limitations are spectral efficiency, bandwidth and latency. On the latency front, HSPA+ cuts the user plane latency dramatically but it is still measured to be around 30ms to 40ms (round-trip delay) for best networks (refer Table I for comparison).

For LTE, being a much newer revolutionary technology, technology designers tried to improve the spectral efficiency by heavy use of multiple input multiple output (MIMO). LTE networks have been deployed with 2x2 MIMO from the start. This allowed the spectral efficiency to be boosted up; reaching peak spectral efficiency of 7.3bit/s/Hz (10MHz bandwidth), with the cell spectral efficiency level of 1.8bit/s/Hz (10MHz bandwidth). Even though LTE was defined for channelisation of 20MHz, 700MHz band, it is not large enough for such large bands to be assigned to a single operator. LTE user plane delay looks comparable to HSPA+ network.

WiMAX is fairly comparable to LTE in terms of spectral efficiency and delay capabilities since these share the same multiple access scheme and use similar modulation and coding scheme. Similar to LTE, WiMAX also uses 2x2 MIMO. WiMAX latency profile is similar to LTE due to



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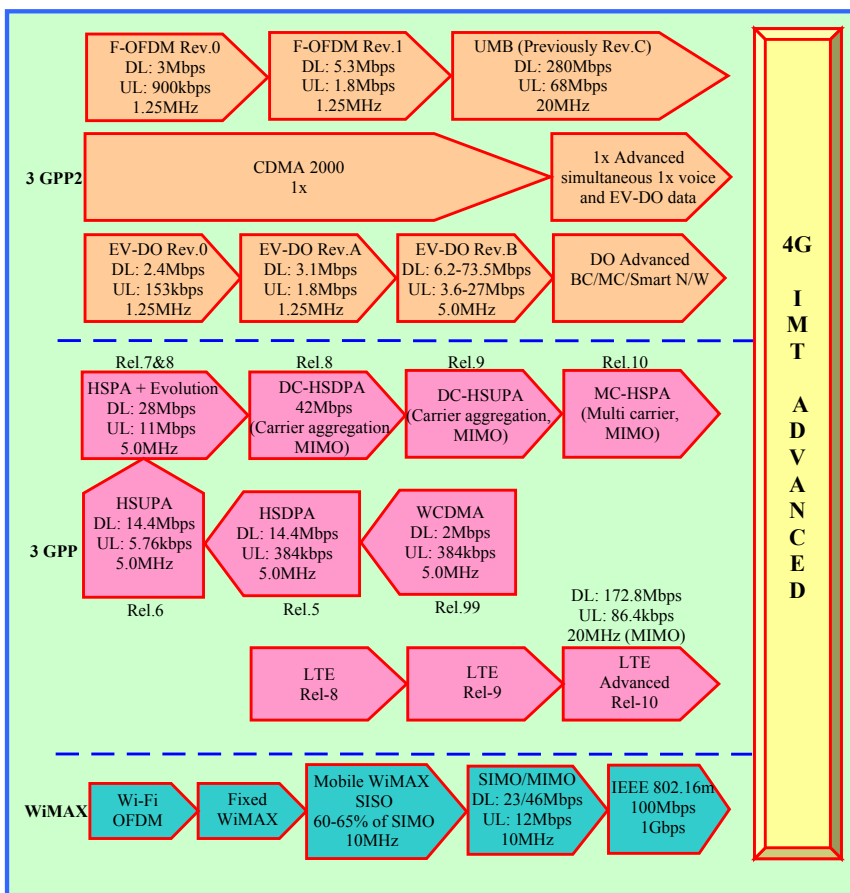


Fig. 1: 4G candidate technologies

flatter network compared to HSPA + , but round trip delays ranging between 100ms and 140ms put WiMAX quite far from IMT-Advanced targets.

Even though none of these technologies are fulfilling the IMT-Advanced criterion, each one has an evolution path to get there. An evolution path to 4G is depicted in Fig. 1.

HSPA + is being expanded to allow 40MHz channelisation with 4x4 MIMO capabilities that allows it to achieve 16.8bit/s/Hz peak spectral efficiency. Details about how to achieve other targets are all part of release 11, which is expected to be completed very soon.

LTE is closer to 4G thresholds compared to HSPA + and was formally submitted by the 3GPP organisation. Primarily, LTE was designed to incorporate MIMO from the start. If 4x4 MIMO is implemented in the terminal form factor to have an LTE-category five devices, then using

LTE-Advanced that allows 40MHz to 100MHz channelisation will bring true 4G capabilities.

LTE-Advanced is part of 3GPP release 10 and is essentially an enhancement to the existing LTE network. This upgrade path makes it more cost-effective for vendors to offer LTE and then upgrade to LTE-Advanced. LTE-Advanced (release 10) has been formally submitted by 3GPP in fall 2009 to achieve high data rates of 1Gbps peak download and 500Mbps peak upload, and it is expected to be released soon.

On WiMAX front, IEEE 802.16m or wireless MAN-Advanced evolution of 802.16e (mobile WiMAX) is under development, with the objective to fulfil the IMT-Advanced criteria of 1Gbps for stationary reception and 100Mbps for mobile reception.

Some other technologies like 1x-Advanced, DO-Advanced and ultra mobile broadband (UMB) are

also rapidly progressing to meet and surpass the IMT-Advanced requirements. Following a detailed evaluation against stringent technical and operational criteria, ITU has determined that LTE-Advanced and IEEE 802.16m/wireless MAN-Advanced should be accorded the official designation of IMT-Advanced, which is considered as 4G.

In a nutshell

The wonder technology 4G is expected to cover the data-rate deficiency in previous generations. It is also aimed to achieve quality of services including voice chat, video calls, MMS, HDTV and voice-over Internet protocol (VoIP). This technology aims to provide 100Mbps data rate for moving users and 1Gbps for stationary users so that they can enjoy uninterrupted connectivity with high speed anywhere they go.

Flawless connectivity and international roaming across innumerable networks of the world is its next target. It is an all-IP-switched network and several working groups propose that it should offer an open Internet protocol. The technology components being considered for 4G include carrier aggregation, advanced access schemes, enhanced multiple antenna transmission, relaying and repeater solutions, among others. In addition to these solutions to enhance coverage and cell edge data rates, an evolution of inter-cell interference co-ordination in the form of coordinated multi-point transmission/reception is yet another technology to enhance the 4G network performance.

4G candidate technologies are LTE-Advanced, wireless MAN-Advanced or mobile WiMAX 802.16m, 1x-Advanced, UMB, DO Advanced and MC-HSPA. Recently, ITU has determined that LTE-Advanced and wireless MAN-Advanced should be accorded the official designation of 4G. Capabilities of IMT-Advanced/4G systems are being continuously enhanced in line with user trends and technology developments. ●

An Introduction to Wireless Multimedia Sensor Networks

Prof. Arjav A. Bavarva is working at Department of Electronics and Communication, School of Engineering, RK University, Gujarat

Dr Preetida Jani is working at Department of Electronics and Telecommunication, Sardar Patel Institute of Technology, Mumbai

Tiny wireless devices and the enormous growth of wireless communication technologies have already established the stage for large-scale deployment of wireless sensor networks (WSNs). A typical WSN consists of a large number of small, low-cost sensor nodes, which are distributed in the target area for collecting data of interest. Most of the time, WSN is used for monitoring, tracking and event management related applications. WSN is not a new topic as many inventions have been done and countless applications have been successfully implemented.

Fig. 1 and Table I show the similarities and differences between ad hoc wireless networks, wireless sensor networks and wireless multimedia sensor networks (WMSNs). All these networks are used for small-scale and medium-scale networks that do not require a fixed architecture and can be deployed temporarily. WMSN requires a novel architecture, and the advanced protocol design and algorithms need to be implemented to fulfil the criteria. This article exposes the internal structure of the multimedia sensor node,

architecture of WMSN, their challenges, research opportunities and applications.

Internal structure of the multimedia sensor node

Normally, a multimedia sensor device includes a sensing unit, processing unit (CPU), communication module, co-ordination subsystem, storage unit and an optional mobility/actuation unit. Sensing units usually have two sub-units: sensors [digital micro cameras, microphones and/or scalar sensors (for example, temperature sensors, humidity sensors, fire sensors, pressure sensors and gas sensors)], and analogue to digital converters (ADCs). Most of the sensors generate analogue signals which should be converted into digital form by using ADCs as these are to be fed into the CPU.

The CPU executes the system software in charge of coordinating sensing and communication tasks for signal processing, and it is interfaced with a storage unit. A communication Tx/Rx module interfaces the device to the network. In many applications, it has been observed that around 70 per cent of the battery is consumed for transceiver processes and the remaining 30 per cent consumption includes computational tasks, signal processing, co-ordination systems and sensor sub-units.

TABLE I
Comparison between Ad Hoc Wireless Networks, WSNs and WMSNs

	Ad hoc wireless networks	WSNs	WMSNs
Node size	Large	Very small	Small
Node density	Very low	High	Medium
Node coverage area	Medium (metres)	Low (metres)	Medium (metres)
Data type	Huge data, like files and audio-visual information	Scalar, like temperature, humidity and fire sensors, among others	Multimedia, like still image, video streaming and voice
Bandwidth requirement	High	Low	Medium
Congestion control algorithm requirement	High	Low	High
Power consumption	Does not matter	Very low	Low

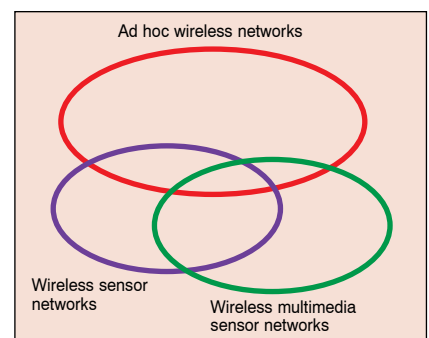


Fig. 1: Classification of different types of wireless networks

TABLE II
Overview of the Features of Hardware Platforms for WMSNs

Device name	Manufacturer	Processor	Memory	Multimedia support	Wireless
Stargate	Crossbow	Intel PXA-255 Xscale processor at 400MHz	32MB flash, 64MB RAM	High computation power, embedded Linux OS	802.11 compact flash, 802.15.4 through MICA2/z interface
Imote2	Intel	32-bit PXA271 Marvell processor at 13MHz-416MHz	32MB flash, 64MB RAM	MMX co-processor for audio/video imaging acceleration	Integrated 802.15.4
CMUcam3	CMU	32-bit NXP LPC2106 microcontroller at 60MHz	128MB flash, 64MB RAM	On-board cc3 open source image-processing library	—
MeshEye	Stanford University	32-bit ARM7TDMI RISC processor at 55MHz	128MB flash, 64MB RAM	Multiple resolution support	—
WiCa	XNP and Philips Research	IC3D Xetal II processor at 84MHz	10MB RAM	Dedicated parallel processor, multiple camera modules	—
Cyclops	Agilent	8-bit ATMEL ATmega 128L microcontroller	512KB flash, 512KB RAM	On-board image processing, low power, cost and size	—

(Courtesy: Akyildiz et al.: Wireless multimedia sensor networks: applications and test beds)

A coordination sub-system coordinates the operation of different network devices by performing various tasks, such as network synchronisation and location management. A mobility actuation unit can enable the movement or manipulation of objects, like motor, to track the object. The whole system is powered by a compact power unit that may be supported by an energy-scavenging unit, such as solar cells. Table II gives an overview of the features of hardware platforms for WMSNs.

WMSN architecture

Fig. 3 shows the reference architecture of a WMSN, which is classified as single-tier and multi-tier architecture. Before we discuss further, it is important to know about the functionality of all components used in this architecture.

Standard audio and video sensors capture sound, still or moving images and videos of low resolution. Scalar sensors are another type of sensors that sense scalar data and physical attributes, such as temperature, humidity and pressure, and report measured values to their cluster head. These are typically resource-limited devices in terms of energy consumption, memory storage and processing capabilities.

Multimedia processing hubs behave as cluster heads. These devices have comparatively large computational resources and are suitable for aggregating multimedia streams from individual sensor nodes. This can be done by

various algorithms implemented in it. Algorithms are capable of managing flow of control (frames per second) by adding and discarding frames. Finally, it is capable of reducing both the dimensionality and volume of data conveyed to the sink and storage devices.

The storage hub allows data mining and feature-extraction algorithms to recognise essential characteristics of the event, even before the data is sent to the end user. The sink is a common data-gathering point of IP-less networks. It also supplies filtered data to the user at the remote end, gathered by a WMSN. Multiple sinks may be required in a large or heterogeneous network.

The gateway creates a bridge between an IP-less network and IP based network. It is an IP-addressable component of the WMSN. It gives permission to the user to monitor and control the WMSN from a remote location as it has an IP address and the capability to create a connection with the Internet.

At the end, users are at the highest end of the hierarchy. They are typical-

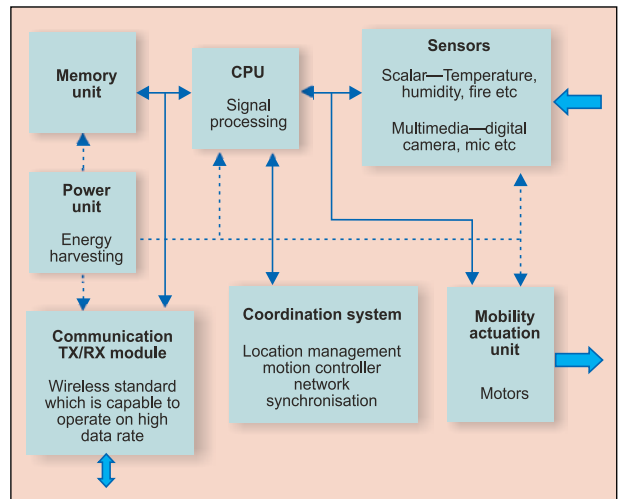


Fig. 2: Block diagram of a multimedia sensor node

ly identified through their IP addresses and run application-level protocols and software that assign queries and display results obtained from the WMSN.

Single-tier means the network is without hierarchy, and cluster is directly connected with the sink. Figs 3(a) and 3(b) show a single-tier architecture, which can be arranged in a flat or clustered manner. Flat topology means all nodes have essentially the same role.

In cluster topology, a group of nodes form a cluster, and the geographical target area is divided into numbers of clusters. Each cluster has one cluster head and one cluster member. In a cluster, two members cannot communicate directly, as shown in Fig. 3(b).

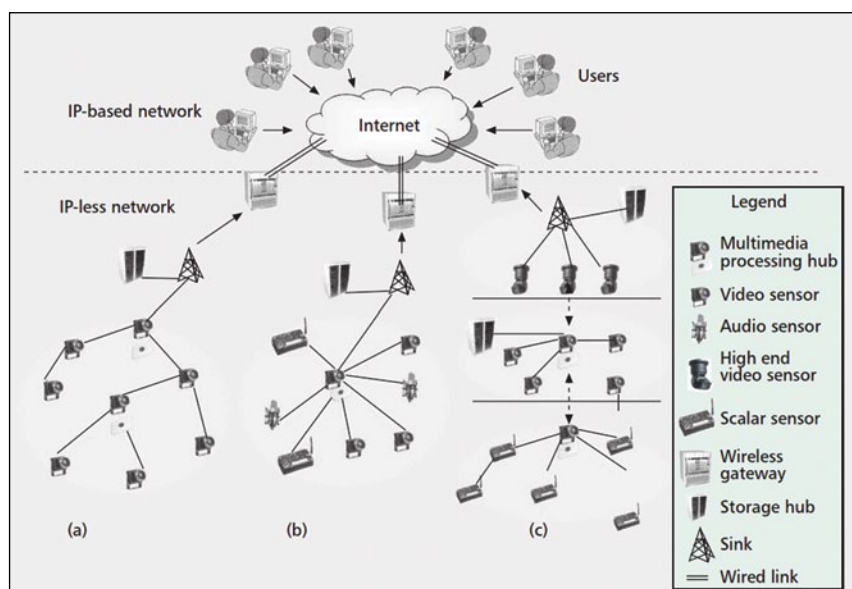


Fig. 3: Reference architecture of a wireless multimedia sensor network: (a) single-tier flat homogeneous sensors, distributed processing, centralised storage; (b) single-tier clustered, heterogeneous sensors, centralised processing, centralised storage; and (c) multi-tier, heterogeneous sensors, distributed processing, distributed storage (Courtesy: Akyildiz et al.: Wireless multimedia sensor networks: applications and test beds)

All cluster members send data to the cluster head, and hence the cluster head has the highest priority to allocate the channel for further communication. For any cluster member, inter-cluster and intra-cluster communication takes place via the cluster head.

Node with the highest energy is selected as cluster head as it consumes more energy. Special algorithms and protocols (for example, LEACH) elect the cluster head on the basis of remaining battery life (RBL) of all nodes within the cluster. A cluster that includes a variety of sensor nodes is called a heterogeneous cluster sensor network (Fig. 3b).

A multi-tier architecture is arranged in hierarchy or multiple layers. As shown in Fig. 3(c), one cluster has formed of scalar nodes and the other using video sensors. Both clusters forward the data to the sink through high-end video sensors. The sink is connected to the Internet (IP based network) via a wireless gateway. This way the user can monitor and control targeted areas from a remote location.

Challenges and opportunities

High data rates. WMSNs require high data rates as data is in terms of

live video streaming, audio and still images. Achieving high data rates (in terms of Mbps) on available narrow channels is a challenging task. Recently, researchers started to implement ultra-wide band (UWB) technology on sensor nodes for higher data rates.

Signal detection and estimation.

Signal detection, estimation, filtering, data gathering and wireless channel separation are still open research challenges for the implementation of WMSNs. Researchers have proposed OFDMs (frequency-division multiplexing schemes) to increase data rates and remove interference between two wireless channels.

Reliability. High information assurance is expected in WMSNs, and for that effective error detection, correction code with accuracy, robustness, resiliency and retransmission policy need to be found out.

Energy efficiency. Nodes have limited battery and, for most applications, charging and replacement of the battery is not possible. Nodes need to serve for many years. To reduce power consumption, researchers have already started designing and implementing different types of MAC protocols [real-time independent channels (RICH)

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MAC protocols, frame sharing (FRASH) MAC protocol, cluster based on demand multichannel MAC protocol, Q-MAC, RL-MAC and many more]. Energy efficiency can be obtained by implementing new algorithms on the physical layer (modulation techniques, architecture, etc) as well as on the MAC layer. Many image- and video-compression algorithms are also introduced, for instance, distributed video coding (DVC), high-efficiency video coding (HEVC), discrete cosine transform (DCT), discrete wavelet transform (DWT) and curvelet transform. Results show that by using advanced compression techniques, energy consumption can be reduced by up to 50 per cent.

Inherent uncertainty. In most WSNs, mobility of nodes creates problems as it affects topology, routing protocols and synchronisation. Coverage area and coherence bandwidth depend on moving obstacles and the surrounding environment.

Security and privacy. Multimedia industrial monitoring and control kind

of applications require high privacy and security. Unauthenticated persons should not be able to access private data.

Quality of service (QoS) and quality of information(QoI). High QoS and QoI are required on each and every communication layer. The resolution should be good enough at remote places. For video streaming, 5fps to 20fps (frames per second) is expected for better quality, and all layers should be designed accordingly.

Applications

WMSNs have numerous killer applications. Multimedia surveillance sensor networks can be used to enhance and complement existing surveillance systems to prevent crime and terrorist attacks. These can be used to locate missing persons, identify criminals or terrorists and record other potentially relevant activities, such as thefts, car accidents and traffic violations. With the help of WMSNs, it will be possible to monitor car traffic in big cities

and on highways that offer traffic-routing advice to prevent congestion or identify violations.

WMSNs play a vital role in personal health care units. Telemedicine sensor networks can be integrated with 3G and 4G mobile networks to provide ubiquitous health care services. Patients can carry various types of medical sensors to monitor different parameters, such as blood pressure, ECG, breathing activity, pulse oximetry and body temperature. Remote medical centres or personal doctors can monitor the condition of patients to infer emergency situations. This will be more beneficial for villages and rural areas where doctors and health centres are not available all the time.

WMSNs can also be used for environmental and structural monitoring purposes. Video and image sensors may be used to monitor the structural health of bridges and other civil structures. In industrial applications, WMSNs can give visual inspections and automated actions. ●



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New T&M Tools for Academia Boost Learning, R&D and Industry Readiness



Abhishek A. Mutha
is a senior technical
correspondent at EFY

Test and measurement (T&M) companies have been serving the education vertical for a very long time now. The education sector consumes a variety of products ranging from basic instruments, like power and signal sources, to oscilloscopes, analysers and digital multimeters. T&M instruments are vital to any electronics lab.

Apart from being high on the ease-of-use and learnability factor, today's latest T&M equipment provide a platform for students to bring their imaginative ideas to life and develop their skills right from basic engineering to advanced level. Available at pocket-friendly prices to expensive but highly featureful, these instruments also aid academicians in their research and development (R&D) activities as well as performing and writing up new experiments. Let us take a look at the current trends and latest arrivals in the T&M domain targeting colleges and universities.

Emphasis on adapting industry-grade products for academia

Industry experts feel that the trend of products singularly manufactured for academia has decreased over the years. Although some

of the T&M companies produce instruments particularly targeting the education sector, others are focusing on pitching industry-grade products for academia, be it oscilloscopes, spectrum analysers, signal generators or even digital multimeters today.

Employing the same full-featured set of T&M tools operated by professionals helps students to comfortably transition into the industry without having to start from scratch. Talking from National Instruments' philosophical standpoint, Satish Mohanram, technical marketing manager, National Instruments, says, "We believe in teaching engineering through experiential learning. Therefore we feel there should be no separation between T&M tools used by academia or industry."

He adds, "When we come up with a product, apart from it being used by the industry, we consider in getting students trained on that tool as they learn their engineering so that eventually when they graduate, they do not have to start from scratch in learning new tools to become productive. From that standpoint, we have been launching quite a few products that significantly affect the industry and could be used in the academic scenario to teach some really important concepts very effectively."

For academia, Keysight Technologies provide the same equipment that they provide industries for T&M measurement purposes. There is no specific focus on products for academia. Pathy V.V., business development manager-education, Keysight Technologies India Pvt Ltd, says, "Academia is just one of the markets. We have launched products for all domains." He adds, "We identify what makes sense for education and then position those products for educational institutes."

View point: Why academia should switch to digital storage oscilloscopes and use industry-grade T&M instruments

Today, I find a lot of colleges still using analogue oscilloscopes. We are advising them to switch to digital storage oscilloscopes with at least 50MHz bandwidth. If you look at oscilloscope measurements today, no industry uses analogue mode. As a matter of fact, there are hardly any analogue radios visible today.

Also, the reason for not focusing on making products particularly for academia is because we want them to use the very same equipment that they will see when employed in an industry. When they enter the industry, they should be able to immediately use that equipment without starting from scratch. When we set up labs in academic institutes, we offer the very same model but they get a benefit in price. By using the same equipment, budding engineers become eligible for technical jobs.

Depending on academic needs, basic oscilloscopes are available for undergraduate teaching and advanced research, and oscilloscopes with high bandwidths are preferred.

—**Pathy V.V., business development manager-education,
Keysight Technologies India Pvt Ltd**

Current focus areas of T&M companies for academia

Apart from recommending industry-grade tools for colleges and universities, T&M vendors are introducing teaching kits and labs to ease the learning and teaching processes for students and academicians, respectively. Today, oscilloscopes are also embedded with training-mode features, enabling users to investigate and educate themselves.

From a product perspective, Keysight focuses on three areas for educational institutes. Pathy says, “One is basic equipment for faculty and students who can use and put together some experiments. Next are teaching labs that are a bundled solution, where we not only provide the equipment but also teaching kits. Last offering focuses on postgraduate (PG) curriculum and research in a chosen domain.” He goes on to add, “For example, at Keysight we have equipment and design tools for anything to do with electronics, be it radio frequency (RF), wireless, nanotechnology, high-speed digital or semiconductor. If a college has a PG program on wireless communications, we have solutions where we supply the complete lab—equipment, teaching kits, design solutions and even structured training programs for faculty.”

Companies like Tektronix and Rohde & Schwarz are focusing on incorporating an integrated courseware system and training mode into their instruments, respectively. To help students and professors acquire in-depth knowledge through their instruments, Scientech Technologies is working on high-end VLSI products and automated test equipment (ATE), which can help students get the actual feel of ATE testing processes.

Amol Kadu, regional manager-west region, Scientech Technologies Pvt Ltd, says, “Our main principle has always been to make students feel that engineering is not rocket science, by providing them with equipment that make their life easier while studying. These equipment are aimed to help teachers and students grasp the

subject effectively.” He adds, “We are also upgrading our oscilloscopes that can be used as ATE rather than just conventional oscilloscopes. Our DesignLab is the first breakthrough in this segment of ATE.”

Anritsu has partnered with Elliptika to come up with a product called Eduktika, which is a microwave teaching kit for students at colleges and universities. Anritsu’s VNA Master series of handheld vector network analysers is part of this solution, which can be utilised by academicians to enlighten students on fundamentals of RF and microwave technologies. This mostly serves the market outside India. For Indian market, Anritsu has developed an RF and microwave trainer kit in association with Foundation for Innovation and Technology, IIT Delhi.

New entrants in T&M equipment for education

There were quite a few industry-specific products released in the last one year, also suitable for academia and specifically just for educational institutions and universities. Select products have been talked about in detail below.

All-in-one instruments. There is a whole set of people designing circuits and systems, and making measurements with the help of benchtop instruments. Six months back, with the intent of making benchtop instrumentation easy, NI came up with a product called VirtualBench (refer to table for more information). “Even though technology has changed in different areas of automated test, advancements for benchtop measurements have been very limited,” feels Mohanram. VirtualBench is a combination of a function generator, oscilloscope, digital multimeter, high-speed logic analyser and power supply integrated into a single equipment, programmable using LabVIEW. There is also an option for users to not program the device by simply using it as a plug-and-play instrument via USB or Wi-Fi connectivity.






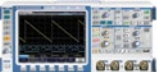


With a ready-to-run application for Windows based PCs and iPads, users can control and view all measurements on the device’s screen. Mohanram informs, “For the industry, it enables a generation of signals and measurement on a single device rather than having multiple instruments for multiple tasks. For academia, VirtualBench is available at a relatively lower price, which has helped a lot of electronics labs re-look at their current set-up and replace their existing box-type instruments.” He adds, “This is one instrument that is helping academicians change the way they have been doing measurements in electronics, or any lab for that matter.”

Scientech’s PC based instrument, DesignLab, looks to make it easier for students with a seven-in-one equipment, which has a digital storage oscilloscope, function generator, 16-channel logic analyser, pattern and word generator, and variable power supply. Kadu says, “DesignLab helps students and professionals to have hands-on experience, realise proof of concepts and their projects.” He adds, “Educational institutions, like IITs, NITs and some other engineering and polytechnic colleges, are users of Scientech products, as we have solidified their trust in our products over the years now.”

Although expensive, Tektronix’s MDO3000 series of mixed domain oscilloscopes benefit engineers and educational institutes into R&D by offering the functionality of six independent instruments, namely, spectrum analyser, logic analyser, protocol analyser, arbitrary function generator and digital voltmeter (DVM). On the flip-side, only three functions (oscilloscope, spectrum analyser and DVM) are standard, others cost extra.

Benchtop digital oscilloscopes. Keysight has some new introductions where they feel that the improved user interface will allow students to use the instrument in a much more effective manner. Pathy says, “We have introduced a scope called 3000T with a much better user interface.” These 3000 X-Series oscilloscopes

Latest T&M Tools for Academia

Company	Product type	Model	Features
Anritsu	Vector network analyser 	VNA Master MS2025B	<ul style="list-style-type: none"> 2-port, 1-path vector network analyser (VNA) with user-defined overlays for viewing multiple S-parameters and IF bandwidth selections of 10Hz to 100kHz Intuitive graphical user interface (GUI) with convenient touchscreen 100dB transmission dynamic range and 850µs/data point-sweep speed
GW Instek	Digital oscilloscope 	GDS-2000E series	<ul style="list-style-type: none"> 200MHz/100MHz/70MHz bandwidth selection; two- and four-channel configurations, 20.3cm (8-inch) WVGA TFT LCD 1GSa/s real-time sampling rate for each channel (2-channel model); 1GSa/s maximum real-time sampling rate (4ch model) Max. waveform update rate of 120,000wfms/s, FFT display of 1Mpt and low background noise
GW Instek	Arbitrary function generator 	AFG-100/200 series USB modular type	<ul style="list-style-type: none"> Frequency range: 1µHz~25MHz; 1µHz frequency resolution, USB interface signal control Built-in 120 MSa/s, 10-bit resolution and arbitrary waveform editing function with 4kpt memory Dual-channel models support coupling, tracking and phase functions Square waveform can adjust the duty cycle from one per cent to 99 per cent
Keysight	All-in-one digital oscilloscope 	InfiniiVision 3000T X-Series	<ul style="list-style-type: none"> 21.6cm (8.5-inch) capacitive touch-screen Includes optional digital channels, hardware serial protocol decode and triggering, built-in arbitrary waveform generator, DVM and an eight-digit counter and totaliser Update rate of one million waveforms/s
National Instruments	All-in-one instrument 	VirtualBench	<ul style="list-style-type: none"> 100MHz, two analogue, 34 digital channels mixed-signal oscilloscope, up to 20MHz (sine), 5MHz (square) function generator, 5½ digits resolution digital multimeter, programmable DC power supply, and eight digital I/O channels
Rohde & Schwarz	Digital oscilloscope 	RTM 200MHz	<ul style="list-style-type: none"> 200MHz bandwidth and an education mode that deactivates special measurement tools to help students quickly learn how to work with an oscilloscope Sampling rate of 5GSamples/s and a memory depth of 20Msamples Two or four channels, as well as the optional R&S RTM-K32 digital voltmeter available
Tektronix	Digital oscilloscope 	TBS1000B-EDU series	<ul style="list-style-type: none"> 50MHz, 70MHz, 100MHz, 150MHz and 200MHz bandwidth models Up to 2GS/s sampling rate (10x oversampling) PC courseware editor tool, integrated courseware and web resource centre 17.8cm (7-inch) high-resolution WVGA display, five-year warranty Auto-set enable/disable functionality, 34 automated measurements, dual-channel frequency counters
Tektronix	Spectrum analyser 	RSA306	<ul style="list-style-type: none"> Full-featured spectrum analysis capability with included Tektronix SignalVu-PC software 9kHz to 6.2GHz frequency range covers a broad range of analysis needs +20dBm to -160dBm measurement range

(refer to table for more information) are touted to be perfect for teaching labs as these come with a choice for arbitrary waveform generator (AWG), function generation, digital channels and a touch-screen enabling students to swiftly master the operation of the scope, just like their mobile phones or tablets. For academia, these oscilloscopes offer an X-Series

education kit (option EDK) that combines 11 built-in training signals with documented hands-on labs, teaching students how to operate and master modern oscilloscopes.

With bandwidth selections of 70MHz, 100MHz and 200MHz, GW Instek's recently launched GDS-2000E series (refer to table for more information) digital storage oscilloscopes

offer two- and four-channel configurations and comes with low-noise amplifying circuit that can improve overall noise interference to produce genuine signal demonstration.

The RTM 200MHz oscilloscope (refer to table for more information) from Rohde & Schwarz targets universities and training institutes. It features a training mode that disables

MAJOR CONTRIBUTORS TO THIS REPORT



Amol Kadu
regional manager -
west region, Sciencetech
Technologies Pvt Ltd



Madhukar Tripathi
senior manager -
marketing and channel
sales, Anritsu India
Pvt Ltd



**Naresh
Narasimhan**
country marketing
manager, Tektronix
India



Pathy V.V.
business development
manager - education,
Keysight Technologies
India Pvt Ltd



**Satish
Mohanram**
technical marketing
manager, National
Instruments



Sumit Sharma
marketing manager -
India, GW Instek

specific measurement automation functions to push engineering students to explore results on their own and learn how to handle more basic measurement functions. It is also suitable for general-purpose measurement tasks in R&D, manufacturing and maintenance.

Teaching labs/design suites.

Talking about teaching labs, Pathy informs, "On the digital communication side, we have introduced a new teaching lab that educates students on digital modulation/demodulation techniques." He adds, "For instance, consider a GSM phone. What does a GSM signal look like? The teaching lab focuses on such aspects."

As mentioned before, Anritsu has developed an RF and microwave trainer kit with Foundation for Innovation and Technology, IIT Delhi. Madhukar Tripathi, senior manager - marketing and channel sales, Anritsu India Pvt Ltd, informs, "This kit contains many passive components that are tested using Anritsu's vector network analyser (VNA). This gives a good overview for students to learn about real telecom components and their behaviour."

Traditionally, if somebody has to design a communication system, he or she has to go through a very tedious process of coming up with an algorithm. Mohanram says, "In India, due to lack of tools that can take those algorithms on to a physical hardware, a lot of research would get stuck at theoretical level. LabVIEW communication system design suite is one tool that helps take those designs, whether an algorithm written in language C or

LabVIEW, directly to a hardware and validate the designs very quickly." It also helps people convert and optimise some of the algorithms for FPGAs, wherever required.

The hardware known as the universal software defined radio along with LabVIEW communication system design suite together have helped academicians, who are researching or learning concepts in communication, to go leaps and bounds from their theory, putting all of it to practice, claims Mohanram. He says, "This is another interesting product that we have launched recently, which is now being used across academia and industry for learning, researching and implementing radio communication."

Initiatives by T&M vendors for academia

On the semiconductor side, government has recently approved setting up of two semiconductor fabrication plants (fabs); one in Gujarat and the other one at Noida, informs Pathy. He says, "We are actively engaged with Tier I institutes, such as IIT Gandhinagar, that are close to the new fab ecosystem." He adds, "We are helping students with courses. For example, there is one credit course that is developed and conducted by a technical person from Keysight."

Anritsu too conducts workshop seminars in engineering colleges and universities, and updates students with recent technological advancements. Tripathi says, "These sessions are followed by hands-on, live demo of products."

Keysight is also playing the role of an enabler in connecting some of the engineering colleges with the industry. Pathy says, "For example, R.V. College of Engineering in Bengaluru has set up a wireless lab. But by simply buying tools and providing training, it is not necessary that the students would be job-ready. Therefore we are trying to bring industries in and

around Bengaluru to start interacting with faculty of the college." For the industry to interact, there must be good infrastructure support available, like at R.V. College, which motivates them to start such an engagement. He adds, "From a college perspective, the very same interaction can also help the faculty to know some of the R&D programmes that these industries are into and general technology trends. Students are also given an opportunity to interact and understand job requirements in this industry."

Talking about National Instruments, Mohanram says, "We have always been doing hands-on workshops that happen almost on a weekly basis at our office, and these can be attended by both industry and academia before these take on the product and start using it."

Keysight has made significant investment into their R&D facility in India. Pathy says, "With our R&D team's help, we are able to offer a six-month student internship programme. This is targeted at students in the PG curriculum." He informs, "The student has access to our equipment and tools, and is also mentored by our R&D team. There is a sense of learning and contribution at the same time, as the student is involved in an active project."

T&M products that are there in the market help people measure and relate to what they learn. Today, T&M vendors are playing a significant role in making sure that students and academicians learn the concept they hear about very effectively using their tools. ●

Control Everything with Your Hand



Anagha P. is a technical correspondent at EFY

We all have heard about legends in every religion and culture across the world, supernatural humans who have the power to control things by simply moving their hands in the air. Such an all-mighty life is not far away, proves a Bengaluru based start-up, Tomar Technologies Pvt Ltd.

Prime, a wristband, is one of these new-generation products that give similar power to its users. It has the potential to let you control almost all electronic devices around you with simple hand gestures. On wearing this band, the user can increase the speed of a fan by rotating the hand clockwise, or reduce the television volume by lowering the hand with palms facing downwards. This band can continuously monitor the user's health too. The LCD screen on the band lets the person control each device's function when he or she points the hand towards it.

The story behind

"The major reason why we came up with such an innovation is because of my sister-in-law's mother," says Hemant Singh

Tomar, co-founder of Tomar Technologies. "She was suffering from pain in knees and it was very difficult for her to walk." This is when they had the idea of controlling a device or process without physically touching it.

"Imagine you do not have to use the remote control," adds Rohit Singh, co-founder of Tomar Technologies, "and you can control all devices by pointing towards these and using hand gestures." Another situation where Prime can be helpful is when you enter the room at night and cannot find the switchboard or remember the exact location of the switch.

Magic trick revealed

The technology used here is based on the theory called the disturbance theory. All

types of activities inside a closed space cause a disturbance inside that space.

Prime considers any system as a 3D model with X, Y and Z coordinates. Hand movements happening in this model are captured and converted into their 3D coordinates. Prime's intelligent network pre-trains the set of coordinates corresponding to each gesture and starts listening to the gestures it is trained for. When coordinates of the user's gesture match any of the network's gestures, it is identified and an equivalent function is performed. The system learns user patterns and adapts accordingly to create the most accurate results.

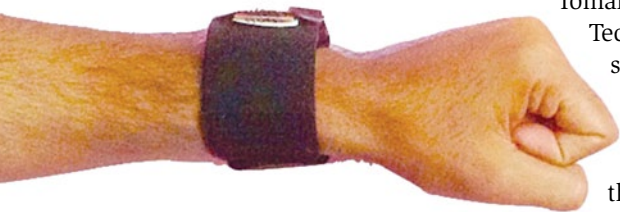
The second part is the indoor positioning system (IPS), which uses several technologies other than satellite in order to locate an object or person inside a closed space. A global positioning system (GPS) works well outside a building, but fails when you have to identify the exact location of a device inside a building.

Team Tomar is working on a coordinate-location mechanism that is much localised and can work inside any building. When the automation system is being installed, coordinates of all devices to be automated are located beforehand. This makes identification of devices easier when pointing one's hand towards it.

Other similar devices

There are multiple wearables, gesture-recognition based products available in the prototype form today. Fitbit is a wearable band, concentrating on the health-monitoring sector. Myo, the gesture-controlled armband by Thalmic Labs, is a band that allows the user to control gaming, smartphones, smart homes, presentations and other such activities by tracking muscle movement. Reemo is another device in prototype form that serves as direct competition to Prime.

An Indian based start-up has come up with Fin, a ring that lets you control



Devices that can be controlled

IR devices	Televisions, air-conditioners, radios, music systems
Digital devices	Computers, game consoles, mobile phones, tablets
Energy controls	Thermostats, smartfans, vents, in-floor meetings, fireplaces
Security	Door locks, smartglasses, window shades, CCTV cameras, control panels
Wiring	Outlets, switches, dimmers
Exterior devices	Garage doors, sprinkler systems

For more information

Device	Prime
Company	Tomar Technologies Pvt Ltd
Website	http://tomartechnologies.com/Tomar1

multiple devices and functions using simple finger gestures. Ring by Logbar is a similar product that lets you control systems with a ring worn on a finger. All these devices are in the pre-order stage, some of these firms having failed to bring out their products almost a year after their promised delivery dates and online crowd funding.

However, the application field of similar devices available in the market is very fragmented. For example, Fitbit is basically for personal health monitoring and Ring is more into home automation. As a user, if I have to get five types of devices for five different functions, that leads to more gadgets, more cost and increased confusion.

Why Prime

The idea behind Prime was to unify all these solutions into a single, small form factor wearable device. The basic set of sensors used in different types of gesture-recognition devices is the same. Team Tomar wanted to create a gadget that could control almost all electronic devices and could be useful for the customer from the time he or she woke up in the morning to when he or she went to bed at night, from increasing the speed of a fan while sitting on a couch to serving as an access card in the office and to continuously monitoring health parameters.

The problem Prime is trying to

solve is to make it natural for users to interact with devices. For example, if you are on a call and the television volume is too high, you can extend your hand with your palm

facing the television (stop signal) in order to mute it. So, Prime identifies the device you are pointing at and identifies the action of the hand in order to perform the intended function.

Many automation devices these days let you control appliances using a customisable mobile app. But a mobile app can be complicated as you have to open the app first and then change the settings. Also, there are different apps for different applications; for example, one app to control the television and another to control the security of the home.

When you point at a device, the line-of-sight is identified in order to select the device. If there are two devices identified in the same line-of-sight, Prime identifies the nearest device. The team is also working on algorithms for identifying a single device from a stack of devices. Gesture recognition is one of the proprietary algorithms that Tomar Technologies has developed and applied patent for.

Spreading across different sectors

As mentioned earlier, Prime would be finding applications across multiple sectors, namely, home automation, gaming, corporate world, and care for the elderly and physically challenged. There are several use cases. People can find their own use cases once they start interacting with this wearable wristband, the developers expect.

Home automation is one segment the team is looking at, as they see a lot of potential in this field in coming years. Tomar is currently planning to tie up with a company in security business. They are also trying to target the corporate sector, hospitality industry and healthcare. In the next two years, the team is planning to develop a healthcare package where vitals of the user will be continuously measured, pulled to the Cloud, analysed and a warning message sent to the doctor when something goes beyond normal.

Prime is currently in its prototype stage and extensive work is being done to reduce the form factor and increase the accuracy of the device. Developers of the product are expecting to get the first batch of Prime into the market by June 2015. The firm is looking at both B2B and B2C monetisation.

Ongoing

Infra-red (IR)-enabled devices do not require any extra set of components for communication. But devices like light, fan and other home appliances have to be fitted with sensors and transmitters, which is done by automation firms. Tomar is partnering with system integrators, automation companies and security solutions providers in order to offer a complete automation solution.

In the B2C segment, the firm is developing a smartswitch (a combination of switch and IR receiver) for devices that are not IR or Bluetooth based. The consumer has to plug the switch in a normal socket and plug the appliance in the socket of this switch. The IR receiver is placed on the appliance, and when you plug it in using the smartswitch, you can control the device.

In short, the wearable band directly controls all IR and Bluetooth-enabled devices like laptops, gaming devices and air-conditioners, and indirectly, using the smartswitch, controls the devices that are not IR or Bluetooth enabled. ●

To Go Boldly Where No Board Has Gone Before



Dilin Anand is a senior assistant editor at EFY

Building projects for flight and space is one of the most popular areas in recent times. From building mini satellites to setting up weather balloons that fly to what is termed as near space, open source hardware and software solutions are driving the poor man's space program.

"Learning to develop engineering skills is like learning to lift weights. You should start with an empty exercise and then keep adding challenges," explains Eben Upton, founder of the Raspberry Pi Foundation, in a recent interview on the eve of Raspberry Pi 2 launch. Open source hardware tools are built to do just that.

Arduino, one of the earliest and most popular lines of open source hardware tools, has had a growing toolset since 2005. Having withstood the test of time, it now enjoys a passionate following of engineers, tinkers and hackers who use it to prototype products and test project designs. In 2015, we now have a vast collection of open hardware developer platforms to choose from.

Over the past decade, we have seen open hardware being used for a variety of projects, including fun projects like building a radio-controlled (RC) car, utilitarian projects like implementing a home media centre or server, all the way to setting up serious industrial automation systems that can control a building. But is that all?

Up above the world so high

Aerospace. That is where the excitement lies these days. During the interview, Upton talked about his favourite kind of project. "I am a big fan of space-style projects, and Dave Akerman is the one who has been doing some fascinating work in sending Raspberry Pi up in weather balloons." The latest iteration of the device features radio telemetry, slow scan digital video (SSDV) images,

a 3G link for video and backup telemetry. It sends a live video stream as well.

Aerospace projects are no more something that governments alone can do. For instance, SpaceX and Elon Musk have made the sector hot from both a commercial and passion standpoint, with its ultimate goal stated to be that of enabling people to live on other planets.

Would you like to...

Let us take a look at how open source solutions have helped build cool aerospace projects, and how you can leverage the same for your aerospace project.

... perform space experiments

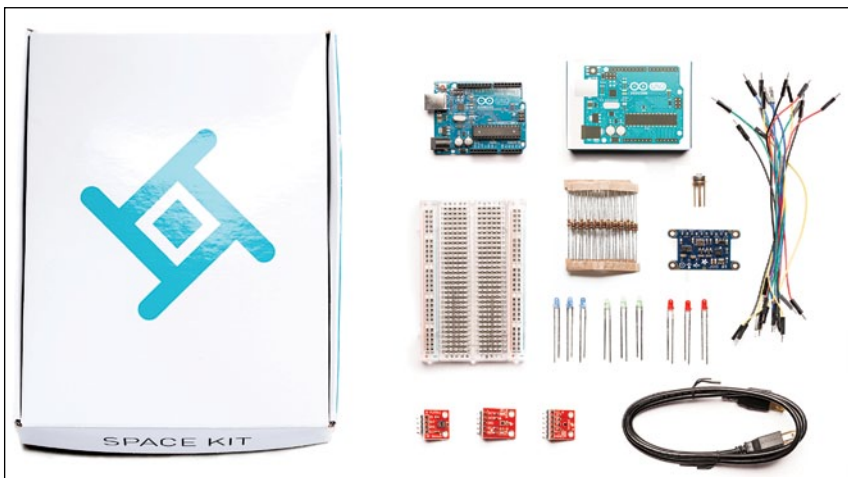
Setting up experiments that can be run in the International Space Station (ISS) is not far-fetched anymore. Explore some of these cool open hardware solutions that will let you do just the thing.

ArduSat

This is probably one of the most famous projects to have taken the humble Arduino and ridden it to space. It is built to the specifications of CubeSat, which was developed by Stanford University, the USA, and California Polytechnic State University, the USA, back in 1999. CubeSat specifications basically call for a 10cm cube that fills up to a volume of exactly one litre, and can weigh up to 1.33kg.

Equipped with cameras, sensors and radios, the project is built to be an open source platform that will enable others to run experiments in space without having to send up a satellite of their own.

ardusat.com is a very good source for learning resources. Set up with the aim to expand science, technology, engineering and maths (STEM) innovation to space, it



ArduSat



Astro Pi



ArduLab

“I would like to die on Mars, just not on impact” — Elon Musk, CEO of SpaceX, at SXSW 2013

an infra-red camera module attached to it.

The foundation also set up a competition to promote code development, which is set under five themes, namely, spacecraft sensors, satellite imaging, space measurements, data fusion and space radiation. This event has several space agencies involved, such as the UK Space Agency, European Space Agency, ESERO-UK, Airbus DS, National Nuclear Laboratory and the National Physical Laboratory.

ArduLab

Created by Manu Sharma, co-founder of Infinity Aerospace, ArduLab is an ATmega2560-powered platform that enables NASA-approved experiments to be run inside the ISS. The result is a kit that is to space experiments what Arduino is to electronics experiments. It comes with all necessary features and interfaces to kick-start experimenting on the ISS. Atmel claims, on their website, that ArduLab has been used by both school students and NASA-JPL researchers for experimenting.

While it used to retail at more than ₹ 120,000 per kit, the good people at Infinity Aerospace later open sourced the entire project so that you can build it yourself. Their website ardulab.com has detailed plans that will help you to build the three main components of the system; the chassis, electronics and software (ArduLab OS). It also includes a kit that comes with some basic programs in Arduino Sketch File format (*.ino). Ino is a command line toolkit for working with Arduino hardware.

Now that you have all your space experiments set and ready, all you need to do is build a rocket to see how high you can get it.

Rockets: Possible design path

1. Design a basic rocket to launch from the ground (alpha)
2. Make it more powerful (beta)
3. Remove the fins and control via thrusting (candle)
4. (Dreamer?)

—Courtesy: openautics.com

features everything from the basics to features that enable you to understand the numerous sensors that can be placed on satellites and how to use these. It also makes individual space kits available, which include Arduino Uno, lessons on remote sensing, a collection of sensors and other components.

Astro Pi

Would you rather explore the universe on the earthy-named Raspberry Pi? The Raspberry Pi Foundation recently announced that they have teamed up with British European Space Agency (ESA) astronaut Tim Peake to send Raspberry Pis

to space, where these will be connected to the Astro Pi board. How cool is that!

Once in the ISS, these Raspberry Pi computers will be connected to Astro Pi boards, which come loaded with a collection of gadgets and, of course, sensors.

Astro Pi systems will be deployed in a number of different locations on board the ISS, where these will collect the generated data and download it to Earth, where these will be distributed to the teams.

Astro Pi allows students the chance to devise and code their own experiments or apps to run in space. The Astro Pi board or hardware attached on top (HAT) comes with a gyroscope, magnetometer sensor and an accelerometer, as well as a suite of sensors that can detect temperature, humidity and barometric pressure. There is also a camera module and

Gravity development board

Designed to help reduce the cost of space-tolerant electronics, Blaze Sanders designed a board to withstand the harsh environments of space. Some claim this board to be

a good alternative for Arduino Uno, which has been the other preferred prototyping environment. The gravity development board (GDB) started life as the high-power driver for Lunar Wombat, which its creator was

working on for NASA. "We needed a small embedded system that could drive Firgelli L16 linear actuators and act as the control and communication system for the entire Lunar Wombat," he states in an article about the board.

Some of the challenges that face an electronic board designed for space include its ability to handle the vibrations of launch vehicles, heat distribution in a weightless atmosphere (convection does not work in space) and redundancies to prevent single-event upsets caused by radiation.

The GDB is designed for beginners and experts, and can be programmed in four languages, including 12-blocks GUI, SPIN, C and assembly.

The board comes in three forms:

1. E series for Earth based applications where size and ease of development matter,
2. M series for Mars or planetary based applications and
3. S series for free space based applications where rad-hard components are a must. This type also comes with Xilinx Virtex-5Q field programmable gate arrays (FPGAs), allowing reconfigurable hardware.

Would you like to be RocketMan

Ever seen the movie *RocketMan* from 1997 where an engineer gets to ride a rocket to planet Mars? Well, you could start working for your chance at it too, by building some of these electronics projects designed to help control your rocketship.

Altus Metrum

Although they have a collection of open hardware and software designs available at their website, TeleMetrum and TeleMega are the ones at the top of the line. Powered by ST Micro's STM32L151 ARM Cortex M3 based microcontroller (MCU), these both come with TI's CC1120 RF transceivers, u-blox's MAX-7Q GPS receivers and Freescale's MMA6555 inertial sensor, among other components. These boards were designed using the open source gEDA (an open source

How to select a developer board

If one has to implement simple logic based algorithms using basic control loop structures of programming, a MCU based developer kit would be apt. "Arduino and its variants would be easy to learn and allow quick prototyping. Most MCUs have an embedded C based programming environment, although in recent times we have seen Java/.net cross compilers for MCUs. However, C based IDEs are stable and remain the most widely used," explains Darshan Virupaksha, systems engineer, Altix Innovations and co-organiser of IoTBLR.

Computing and power. He adds that if one has more computational requirements like image processing and intends to have faster communications interfaces, Raspberry Pi, Beaglebone or UDOO boards are useful. High-level languages are very well supported on any of these Linux platforms. Since these platforms run some flavour of Linux, prototyping becomes simpler. Hence, for use cases involving all media processing, machine learning algorithms and faster connectivity, one could use the above-mentioned Linux platforms.

All MCU based boards can easily run on battery power. Although Raspberry Pi can be technically supported with just a battery, it is not a viable option. While a MCU based board would support low power requirements (0.3W), the latter would need around 10W of continuous power. Hence it makes more sense to have a MCU based board, like Arduino in these cases.

Cost. Boards like Raspberry Pi are cheaper since their production numbers are quite high. This allows the company to minimise manufacturing cost due to economies of scale, and pass on the savings to the end customer. "It is also much easier to integrate an open source board rather than developing your own PCB from scratch," adds Upton.

"I started my son off with Snap Circuits, and he has moved on to Lego Mindstorms in his local robotics club at school. I would like to see accessibility improve with lower prices, and many boards from major semiconductor companies are already subsidised. But for the best marriage of accessible (that is, low cost) hardware and information, I think Arduino has that nailed," explains Lynnette Reese, technical team lead, Mouser Electronics.

Reduced time to market. "Open source boards have been a great tool for prototyping and R&D, because the boards were well documented and as a result offered much better support compared to proprietary boards," says Eben.

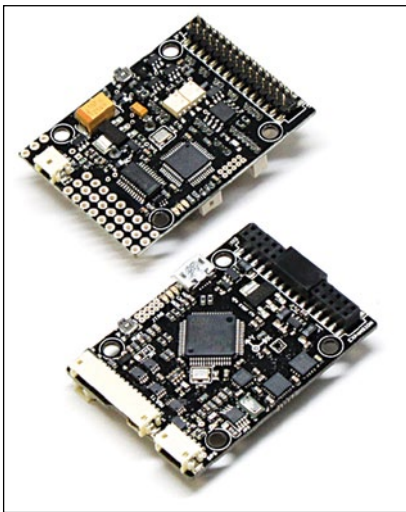
He adds that engineers would also always want to figure out a way to get things done as quickly as possible. Additionally, even with the help of a board, there is still plenty of hard work left in the form of integration.

"Using such platforms is advantageous for product developers as the complete hardware design, firmware, open source OS and reference projects are already available and give them a head start in their product development. The developer will have to only focus on developing the application and ID design (look and feel) to take the product to market," suggests Selvaraj Kaliyappan, vice president - PES Engineering, Mistral Solutions.

Community. "I am a big fan of Arduino and it is kind of the original developer board. It is also good to see that they are diversifying into new kinds of boards," adds Eben. It is also very powerful because it has a very big community, a good flow and also helps with figuring out how to get Atmel chips integrated into your product. Arduino can help you get past these kinds of problems.

The community following is not limited to the Arduino's and Raspberry Pi's of the world though. There are numerous maker groups, organisations and communities doing their own things too. You can meet up with most of them at EFY's Electronics Rocks branded conferences in Bengaluru. The next one is scheduled for January 11-13, 2016, to be held concurrently with EFY Expo 2016 in Bengaluru.

Ganesh Kumar, country sales manager, Atmel, says, "Due to the nature of our MCUs being deployed in a wide spectrum of applications and industries, we have accustomed to servicing not just a few large customers, but long-tail customers, among them many are makers or start-ups. We believe that these currently small players will eventually play a key role in shaping the up-and-coming Internet Of Things (IoT) revolution. According to Garner, 50 per cent of the IoT solutions by 2018 will be provided by start-ups that are less than three years old. We believe that many such key IoT players will emerge from the makers."



PX4 flight management unit (FMU) I/O kit

electronic design automation tool) for schematic capture and PCB layout.

TeleMetrum is recording dual-deploy altimeter for high-power model rocketry with integrated GPS and bi-directional telemetry link. It features a 70cm ham-band receiver for telemetry downlink and integrated support for electronic ignition of pyro stages.

TeleMega is a version of TeleMetrum, which is designed for high-power rockets. Although it sounds like it uses an ATmega chip, it actually runs on ST Micro's MCU. In addition to the features of TeleMetrum, TeleMega also makes it possible to configure pyro events with up to six pyro channels, and can be based on time and various flight events as well as status-like angles from vertical and more.

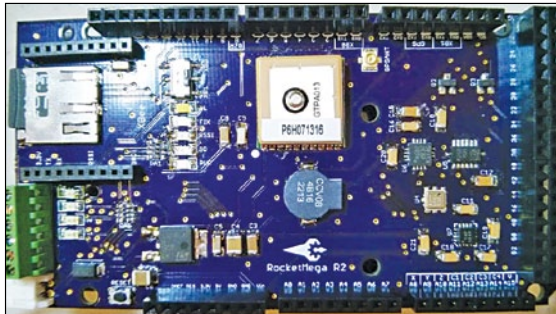
TeleMega firmware runs on an operating system called AltOS, which provides features like flight monitoring, post-flight analysis, device configuration and firmware updation. AltosUI, through which these features can be accessed, runs on Linux, Mac OS X and Windows as well.

Rocket Mega

Designed by OSAerospace to be a low-cost open source platform for development and experimentation in rocketry and other aerospace applications, the Rocket Mega project is based on Arduino hardware.

Major contributors to this report

- **Anmol Agrawal**, UX/UI designer, Interaction-Design
- **Darshan Virupaksha**, systems engineer, Altix Innovations and co-organiser of IoTBLR
- **Eben Upton**, founder, Raspberry Pi Foundation
- **Ganesh Kumar**, country sales manager, Atmel
- **Lynnette Reese**, technical team lead, Mouser Electronics
- **Selvaraj Kaliyappan**, vice president - PES Engineering, Mistral Solutions



Rocket Mega revision 2

What it essentially contains is a Rocket Mega shield, code and an Eagle CAD library that contains custom parts and footprints. Complete details on how to build the board, including bill of materials and schematics are available at opensource-aerospace.com

The R1 version is a shield designed to work with Arduino Mega board. The R2 version comes with several improvements, yet still manages to keep the same price point in raw parts. Improvements include using MOSFETs rather than relays for controlling the pyro channels, apart from shifting to ceramic capacitors, improved routing and fewer individual parts.

TI's MSP430 LaunchPad + CC430 kit rocket launch controller

TI's aptly named LaunchPad development kit combined with a CC430 low-power wireless development kit provides for a good base to build a remote model rocket launch controller with streaming video support.

Digi-Key website's video library has a good video showing the system in action, where CC430 controls the current to the rocket ignition system by using an optically-isolated

MOSFET. Another laptop-connected kit controls a servo that supports video equipment.

Autopilot

The APM Autopilot suite is an open source autopilot solution that includes hardware, firmware and software to run an autopilot vehicle. The firmware

is what contains the skill-set code, which configures the system for the kind of vehicle that you are going to be running. Examples are ArduPlane that allows you to give a fixed-wing plane full autonomous capability and ArduRover that does the same for an unmanned ground vehicle. APM's APM:Rover won the 2013 and 2014 Sparkfun Autonomous Vehicle Competition too, so that gives good credibility to the system.

The hardware that you can opt from for this system includes 3DR Pixhawk, which features an advanced processor and sensor technology from STMicroelectronics and comes with a NuttX real-time operating system (RTOS).

APM 2.6 is another piece of hardware that can be integrated for implementing autopilot features onto the board. It is Arduino compatible but requires a GPS unit and a compass module for full autonomy.

One small step

Do not wait. You are in the golden age for developers, with access to a ton of code and hardware that has already enabled others to develop amazing projects. Start tinkering with these boards to build your dream project. Hopefully, one of these might let you touch base with space: the final frontier. ●

Better Integration and Enhanced Software-Driving Programmable ICs



Anagha P. is a technical correspondent at EFY

Programmable logic device is the name used to describe mainly two types of chips—complex programmable logic devices (CPLDs) and field programmable gate arrays (FPGAs).

“Programmable integrated circuits (ICs) were initially simple, logic based devices,” says Giles Peckham of Xilinx. But now the technology has advanced to a level where programmable ICs that we get these days are highly integrated and have a reduced footprint.

Hardware trends

As in most other fields of electronics, integration and size reduction are the two major trends that manufacturers are working on.

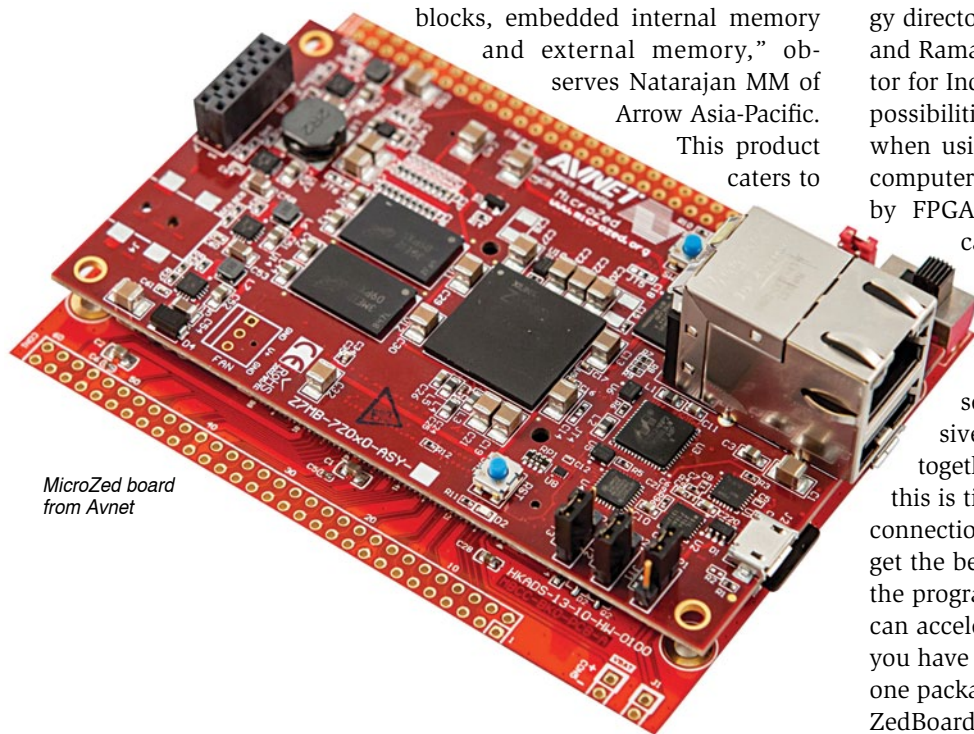
Integrating multiple features. “An exciting development in the field of programmable ICs was the release of flash based FPGA with built-in ADCs, DSP blocks, embedded internal memory and external memory,” observes Natarajan MM of Arrow Asia-Pacific.

This product caters to

the mass market and opens up new markets and new segments, like automotive, industrial, the Internet of Things (IoT) and consumer electronics. He adds, “More integration of hard system/IP blocks, like hard floating point DSP blocks, high-speed SERDES (serialisers/deserialisers), hard memory blocks, analogue-to-digital converters (ADCs) and 32-bit/64-bit ARM processors, is also seen.”

Integration of the processor into an FPGA takes it to the level of a programmable system on chip (SoC). This integration allows for faster system performance and greater flexibility, and allows for designers to differentiate their end-product by customising both hardware and software. It also reduces system cost and increases productivity for designers.

Powering SoMs. In an interaction with Dilin Anand of EFY (featured in this issue of EFY), Avnet’s Bryan Fletcher, technology director for global technical marketing, and Ramani Sundaresan, managing director for India, had mentioned the immense possibilities open to a design engineer when using system on modules (SoMs)/computer on modules (CoMs), powered by FPGAs. With sequential processing capabilities of SoMs and broad massive parallel programmable logic processing capabilities of FPGAs, a programmable SoM powered by an FPGA has both sequential processing and massive parallel processing combined together in a single system. Moreover, this is tightly coupled with thousands of connections internal to the chip. So you get the benefits of a processor and that of the programmable logic, using which you can accelerate the most critical tasks, and you have these very tightly coupled inside one package. Examples of such boards are ZedBoard, MicroZed and PicoZed from



MicroZed board from Avnet

Avnet, Miami SoM from Topic Embedded Products and MitySOM from Critical Links.

An interesting example of an FPGA based SoM application is sensor fusion, where inputs from different types of sensors with different interfaces and different communication protocols are processed in real-time. The processor manages all incoming data sequentially and the programmable IC processes all these inputs in parallel in real-time.

Packaging. The density of an IC package is growing. Bigger designs are made possible with smaller chips. With increased density, the number of chips required reduces. This reduces interconnectivity, thereby decreasing the complexity of the entire design, increasing flexibility and offering better clock timings.

Seamless migration. One feature programmable IC firms offer is easy migration between different models of the same brand. This gives the user the possibility to upgrade from or replace an older, low-end version to the latest, mid-range or high-end version of FPGA.

Enabling tools

Major enhancements have been made in software tools for programmable devices. The software is now available with numerous built-in features that save a designer's time in repeating the design process. Such advanced tools take care of so many factors that make the software much easier to use and increase the designers' productivity by better reporting and increased performance, including common connectivity blocks to accelerate development cycle. Software flow for programmable devices is also becoming more flexible by allowing designers to adopt their own flow or architectures, like MATLAB/Simulink, ARM DS5, OpenCL and high-level synthesis (HLS).

The HLS of Xilinx Vivado design suite allows the user to write programs for ASICs and FPGAs in C and C++ languages, and easily convert

Comparison between CPLDs and FPGAs	
Complex programmable logic devices (CPLDs)	Field programmable gate arrays (FPGAs)
Non-volatile	Volatile
Used in devices that require small gate count	Used in devices that require high gate count
Less complex architecture	More complex architecture
Less cost per package	High cost per package
Logic cells are based on EEPROM flash	Designed using RAM based digital logic chip
Coarse grain type: a few number of large logic blocks	Fine grain type: a large number of tiny logic blocks
Delays are much predictable	Delays are quite unpredictable
For mass markets and small, simple control based designs that require quick response time, fast decoding, ultra-low idle power consumption and design security. For example, battery-operated equipment	Covers a wide range from low-cost, low-end models for simple applications to optimum cost, mid-range models for slightly complex applications to high-cost, high-end models for highly complex applications

these to hardware description languages (HDLs). So, even software engineers can now design with FPGAs. This is a big productivity boost for customers, as many people know C and C++ but not HDL, VHDL and Verilog. Software tools, like software-defined specification environment for networking (SDNet) and SDAccel by Xilinx, are software development environments for FPGAs and/or SoCs. These tools help in better hardware and software partitioning and improve design integrity.

The DesignInsight technology by Tabula, which consists of architecture, chip design and Stylus compiler software, allows real-time observation, debugging and validation of individual logic cells of PLD in real-time (up to 2GHz).

Application and industry specific

FPGAs are programmable for all industries. But there are several stringent certification procedures and requirements to approve a device for certain applications, like military, automotive and medical. Due to this reason major FPGA manufacturers are now introducing FPGAs specific to certain fields of applications. These are becoming more ASIC-like. For example, Altera Enpirion Power-SoCs and Cyclone V SoC FPGAs are automotive grade, Altera Arria 10 FPGAs and SoCs are fully-compliant with military standards, and Kintex

Ultrascale is suited for data centres, video and medical imaging, broadcast systems and radars.

Data centre acceleration. Apart from working closely with CPUs and improving response time, throughput and efficiency, FPGAs these days also make programming and debugging easy by letting designers work in languages and architectures they are familiar with, such as MATLAB/Simulink, OpenCL, ARM DS-5 and HLS. This is a major advantage to data centre programmers.

Network enrichment. The IoT environment is varied and uncertain, mentions Steve Gabriel, corporate communications manager at Altera Corp. The fast, computationally efficient programmable chips are suitable for the IoT segment in terms of power efficiency, time sensitivity and security. These are effective for IoT hubs that have to support a large number of ultra-low-power network protocols, constantly evolving safety and security tasks, and a wide variety of application-dependent, real-time computing loads.

Real-time 3D medical imaging. Medical image processing and analysis are computationally-intensive tasks and require larger memories. The use of programmable chips, like high-powered CPUs and FPGAs, allow real-time, high-speed and accurate processing and analysis of photonic and electronic signals, with high image resolution. It is also

MAJOR CONTRIBUTORS TO THIS REPORT



Anoop Dutta
managing director,
EmuPro Consulting



Bhaskar Das
Robert Bosch
Engineering and
Business Solutions



Giles Peckham
regional marketing
director for Americas
& EMEA, Xilinx Inc.



Natarajan M.M.
vice president
for South Asia,
Arrow Asia-Pacific
components business



Steve Gabriel
corporate
communications
manager, Altera Corp.

comparatively lower priced, flexible, has a longer lifetime and allows continuous update of features and algorithms with the help of software toolsets, such as Altera video and image processing (VIP) suite. This can be used in positron emission tomography (PET), optical coherence tomography (OCT), computerised tomography (CT), X-ray imaging, ultrasound scanning, image guided therapy and so on.

For medical equipment manufacturers. A handheld hardware platform that lets you drag and drop sensor algorithms between the processor and FPGA fabric, and instantly observes resulting trade-offs in performance and power consumption, is being developed by Netherlands based Topic Embedded Products in collaboration with Xilinx. This would serve as a complete clinical reference design platform for medical equipment manufacturers.

In automotive industry. With autonomous driving becoming a reality in coming years, demand for technologically-advanced features, like automated braking, lane tracking, pedestrian detection, traffic sign recognition and parking assistance, have translated into a myriad list of challenges for system designers. With evolving safety, security and reliability standards for a vehicle, FPGAs offer a scalable, highly-reliable and power-friendly platform with reduced form factor and bill of material (BoM). A typical intelligent car has greater than 60 electronic control units (ECUs).

“Designing such a hard, real-time, low-latency gateway unit requires the right combination of hardware and software intellectual properties (IPs), driven by a system software capable of exploiting the best performance from underlying hardware,” says Bhaskar Das of Robert Bosch Engineering and Business Solutions. “The flexibility and scalability offered by FPGAs allow system designers to experiment, benchmark and quickly arrive at an optimal system design that rightly balances hardware and software needs,” he adds.

Which programmable chip is best suited for an application

Here are a few factors based on which the programmable IC for any application could be selected.

Logic requirement. Logic requirement of an application plays an important role in FPGA selection. If the application is simple and requires only about thousands of logic cells, CPLDs can be used. For low- and medium-complexity projects that require a hundred thousand logic cells or more, low-end and mid-range FPGAs are the options. High-end FPGAs with millions of logic cells are used for very complex applications.

System blocks/design requirement. From simple logic cells, programmable ICs have reached a level of high integration where several features and functions, like DSP blocks, PCIe blocks, processors, mixed signals and memory,

are integrated into the chip. Altera’s Arria 10 FPGAs and SoCs have integrated ARM processors, Cypress PSoC integrates configurable analogue and digital peripheral functions, memory and microcontroller on a single chip, and Lattice iCE40 Ultra integrates emerging infra-red remote, barcode, touch, user identification and pedometer functions.

I/O. Input/output requirements, like voltage, SERDES interface standards and others, can be deciding factors while selecting a programmable chip. For example, Altera Arria 10 supports double data rate random access memory (DDR4 RAM) interface with high data rates. Similarly, Xilinx Ultrascale family has a hybrid memory cube (HMC) interface.

Price. The cost of CPLDs is less as compared to FPGAs. Many medium complex designs are more cost-effective at 28nm node of FPGAs. 16nm node is generally for high-end designs and costs more.

What the future holds

Adoption of 14nm FinFET technology has given the programmable industry a much needed boost in terms of high performance, lower cost and lower power, and has bridged the gap between FPGAs and ASICs even closer. Chip manufacturers are now moving towards 10nm technology. Natarajan believes that Intel’s partnership in the programmable space will lead to more breakthrough innovations and allow programmable devices to meet the ever-increasing demand of customers.

Gabriel states that the two emerging trends in the industry—data acceleration and network enrichment—are addressing the need for faster and predictable real-time performance, low-power Wi-Fi and Ethernet connections, and rapidly-evolving device security. “As the industry is struggling to make the IoT work, these two trends play directly into the strengths of, while creating great opportunities for, programmable logic,” adds Gabriel. ●

Prototyping, Designing with FPGA Boards Made Affordable and Absorbing



Abhishek A. Mutha
is a senior technical
correspondent at EFY

Field programmable gate array (FPGA) development boards, like any device following Moore's law, are more powerful and inexpensive than ever before. The amount of logic you can fit on these devices is staggering, informs Mark A. Bowers, co-founder, MicroNova Electronics. He says, "These have evolved from containing simple glue logic to emulating entire processors and churning through complex digital signal processing (DSP)."

Today, developers are interested in choosing FPGAs for designing their prototypes of pre-silicon deliverables due to their moderate portability in nature, informs Sudharsan Palanikumar, senior analyst, Femto Logic Design Pvt Ltd. He says, "We also see that FPGAs are chosen for this prototyping objective for their ease-of-integration method in software

development processes for demonstration."

FPGA platform availability has improved very much in India today. There are many affordable options available, informs Anoop Jose, manager - research and development, Numato Systems Pvt Ltd. He says, "In 2008, one had no option but to import low-cost FPGA boards. And importing even the cheapest board would have costed ₹ 10,000 or more, once shipping charges and import duties were considered."

Industries use off-the-shelf FPGA development boards as proof-of-concept/prototype hardware platform to validate logic, architecture, data flow or performance requirements and eventually custom-build their own product based on FPGA/application-specific integrated circuit (ASIC). Dhiraj Kumar, director, Systems Engineering, Argus Technologies, says, "This specific

Point of view: Tips for beginners looking to buy FPGA development boards

FPGA size not that important. If you are just beginning, you will not likely be creating huge designs. Even the smallest FPGA you can find on a development board will suffice for quite some time.

SoC FPGAs not recommended. While system on chip (SoC) FPGAs are really cool, these are also fairly complicated to work with and definitely not a recommended starting point for beginners. Beginners can experiment with Mojo board, where you get to program Arduino (ATmega32U4) and the FPGA (XC6SLX9) as it aims to simplify getting started with FPGA and digital designing.

Availability of tools and support. The most important factor when looking for a development board is the tools and support offered. If either is lacking, it will make learning how to use the board so much harder. Almost all FPGA development boards are targeted at FPGA developers, not people wanting to be FPGA developers. This is incredibly important and what I feel is the biggest factor setting Mojo board apart.

Tool cost is another major factor. You do not want to drop a thousand dollars on some super-powerful board only to find out that you have to spend another chunk of money to get access to the tools to even work with it. Many larger FPGAs require a licence to work with. I highly recommend avoiding these for as long as possible. Also, some boards may require a JTAG programmer. Xilinx's programmer costs a staggering US\$ 225. Mojo has no hidden costs. All tools are free and the only thing you need besides the board is a micro universal serial bus (USB) cable.

Avoid feature overload. Many development boards are designed to show-off some features of the FPGA rather than be super useful. Too many boards are packed with useless features that take up general I/O pins and drive up the cost. The first (and only) FPGA development board I bought was Spartan-3AN evaluation board. It cost US\$ 230 and had all the features you could think of. However, it only had a handful of I/O pins that were easy to hook up to something I made. I ended up never using this board beyond playing with a few of its demonstrations.

Mojo was designed to be minimal. You have access to basically all I/O pins. If you want some extra feature, you can add it on as a shield. There is no need to jam everything on a single board. Mojo was designed to be used in bigger projects and not just to demonstrate features on the board.

FPGAs are not that complicated. FPGAs are amazing. I fell in love with these when I first learnt what these were. The idea that I could easily create my own digital circuits was captivating. However, I had a ton of help learning about these, and before I had that, I failed to do it on my own. I want to change this so that anyone who wants to learn about these can, without needing a personal mentor or going to school for electrical engineering. I think that FPGAs are seen as more complicated than these actually are, but it is just about getting the right combination of tools and tutorials to really open the doors for many people.

— **Contributed by Justin Rajewski, CEO, Embedded Micro**

Point of view: Suggestions for professionals looking to buy mid- or high-end boards

FPGA density (or how large of a design can fit in to the FPGA). This is more important for advanced-level boards.

Price and on-board peripherals. The less the number of peripherals already available on board, the more additional extension boards users may have to purchase, thereby resulting in higher total cost. For advanced-level boards, sometimes it may be desirable to not have a lot of on-board peripherals because the user can pick and choose the exact functionality by selecting or buying specific expansion boards. There is a cost versus flexibility case here.

Must-have features. Double data rate synchronous dynamic random access memory (DDR SDRAM) and a serial interface is a must if soft processor based (like, Microblaze) embedded system building is planned.

Ethernet. Especially important if planning to run Linux.

Configuration options. Built-in configuration system preferred since USB JTAG cables can be very expensive.

— **Contributed by Anoop Jose, manager - research and development, Numato Systems Pvt Ltd**

user group should consider mid- or high-end FPGA platforms with a broad category of features. It enables them to quickly prototype their sub-systems or system concept without being limited by the performance of FPGA platforms.”

On the other hand, student communities use FPGA development platforms as a learning platform as well as a target platform for their projects and research activity. Kumar says, “This user group should consider easy-to-use, low-cost platform having additional features support through piggyback or daughter cards.” He adds, “With this approach, a user can set up basic development with low cost and add additional interfaces as required, instead of investing into feature-rich, expensive hardware.”

Later in the article we will take an in-depth look at parameters to be considered and some FPGA development boards available in the market that will help you make an informed decision before buying one. Before that, let us take a brief look at how today's FPGA boards are accelerating prototyping and designing.

Today's boards provide faster performance and time-to-market

Increasing FPGA densities, board interfaces, supported connectors for add-on modules from third-party vendors and built-in joint test action group (JTAG) interfaces are making

boards more powerful and capable. These are driving down the overall cost and providing improved timelines for product development. Natarajan M.M., vice president for South Asia of Arrow Asia-Pacific components business, says, “New-generation FPGA boards are equipped with high-speed mezzanine card (HSMC)/FPGA mezzanine card (FMC) connectors, allowing add-on kits from third-party boards to be plugged on base boards designed on Altera's FPGAs.”

Kumar says, “Adding support for various configurations of external analogue-to-digital converter (ADC)/digital-to-analogue converter (DAC) cards, network processing modules and industrial control modules has enabled users to use a common platform with applications having varied signal acquisition, interfacing and performance targets.” He adds, “With re-usability being a requirement today, supporting the use of a common FPGA based prototyping environment for different designs has significant cost and time-to-market advantages.”

Integration of hard floating-point DSP blocks, 64-bit application class processors, up to 1GHz core fabric speed, high system interconnect bandwidth, C based modelling and hardware design with Altera software development kit (SDK) for Open Computing Language (OpenCL) allows for high-performance and power-efficient heterogeneous computing that meets

FPGA platform availability has improved very much in India today. In 2008, one had no option but to import low-cost FPGA boards

customers growing design challenges.

Bowers informs that their goal was to make Mercury development board as friendly as possible for engineers who want to include FPGAs in their projects, be it students making one-time projects or professionals working to prototype their designs. He says, “Users do not have to worry about soldering tiny FPGA packages, providing multiple voltage rails and numerous bypass capacitors, adding an ADC, soldering on a fast external memory or worrying about interfacing with 5V logic. Mercury takes care of all this, leaving the user to worry about the goals of the actual design.”







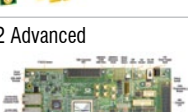


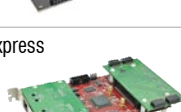


Selecting the right board

Every user will have different needs based on the design, feels Bailey Hsu, director - marketing division, Terasic. Factors such as memory speed, capacity and compatibility with other hardware are pretty fundamental. He says, “The most important thing to look for is the kind of input/output (I/O) expansion on the FPGA development board. A good board must have advanced fundamental features that are accommodating for everyone and at the same time leave enough expansion space for users to connect and expand for their needs.”

Let us take a look at the four most important factors to consider before buying a development board.

Features. The first and foremost factor that affects an engineer's development board selection is the feature set on offer. Bryan Fletcher, global technical marketing director, Avnet Electronics, says, “A board manufacturer helps engineers make this easier by offering multiple product offerings in a full portfolio of development boards and adoptable

Some FPGA Developments Boards Available in the Market Today

Company	Product name	Features	Price
Altera	MAX 10 FPGA development kit	 <ul style="list-style-type: none"> Built around 50k logic elements (LEs) MAX 10 FPGA and includes on-die ADC converter, dual-configuration flash and DDR3 memory interface support Features onboard USB-BlasterTM II, high-speed mezzanine card (HSMC) and PMOD expansion, high-definition multimedia interface (HDMI) output and dual Ethernet 	US\$ 200*
Arrow	BEMI-CROMAX10	 <ul style="list-style-type: none"> Features Altera MAX 10 FPGA with 8000 logic elements, ADC block, temperature sense diode, on-chip RAM, user flash memory and non-volatile self-configuration Extensible via two digital PMOD interface headers Allows for further expansion from two 40-pin prototyping headers 	US\$ 30*
Avnet	Xilinx Artix-7 50T FPGA evaluation kit	 <ul style="list-style-type: none"> Board includes Artix-7 50T FPGA with 52,160 logic cells, 2.7Mbits of block RAM and 120 DSP48 slices Has six Digilent-compatible Pmod connectors, two 10/100 Ethernet connector ports and a USB port 	US\$ 239*
Embedded Micro	Mojo V3	 <ul style="list-style-type: none"> Uses the logic-optimised Spartan 6 Lx9 and ATmega32U4 Includes Spartan 6 XC6SLX9 FPGA, 84 digital I/O pins, eight analogue inputs, eight general-purpose LEDs and onboard flash memory to store the FPGA configuration file 	US\$ 74.99*
MicroNova Electronics	Mercury 200K FPGA w/ 4Mbit SRAM	 <ul style="list-style-type: none"> With a 64-pin DIP package, the core of Mercury is Spartan-3A FPGA Includes an 8-channel 200kSPS ADC, set of bi-directional level shifters to keep the FPGA safe when interfacing with 5V logic and 4Mbit 10ns SRAM USB programming interface and 8Mbit SPI flash memory 	US\$ 70*
Microsemi	SmartFusion2 Security evaluation kit	 <ul style="list-style-type: none"> Comes with SmartFusion2 M2S090TS-FGG484 device that also includes 5G SERDES transceivers Includes a one-year free Libero SoC tool (Development tool used to develop application using Microsemi's SoC/FPGAs) Platinum licence 64Mb SPI flash memory, 512MB LPDDR, PCI Express Gen2 x1 interface, four SMA connector for testing of full-duplex 	US\$ 399*
Microsemi	SmartFusion2 Advanced development kit	 <ul style="list-style-type: none"> Includes SmartFusion2 SoC FPGA in FCG1152 package, DDR3 synchronous dynamic random access memory (SDRAM), SPI flash memory, one pair of SMA connectors, two FMC connectors with HPC/LPC pinout for expansion, headers for I2C, SPI, GPIOs, JTAG/SPI programming interface 	US\$ 999*
Numato Lab	Elbert V2 - Spartan 3A FPGA development board	 <ul style="list-style-type: none"> Features Xilinx XC3S50A 144-pin FPGA with maximum 108 user I/Os and USB2 interface Includes flash memory: 16Mb SPI flash memory (M25P16), eight LEDs, six push buttons and 8-way DIP switch for a user-defined application 	US\$ 29.95* or ₹ 1862*
Numato Lab	Mimas V2 Spartan 6 FPGA development board	 <ul style="list-style-type: none"> Features Xilinx Spartan-6 FPGA with onboard 512Mb DDR SDRAM Includes 16Mb SPI flash memory (M25P16), USB 2.0 interface for onboard flash programming, FPGA configuration via JTAG and USB 	US\$ 49.95* or ₹ 3105*
Numato Lab	Galatea PCI Express Spartan 6 FPGA development board	 <ul style="list-style-type: none"> Features Xilinx Spartan-6 FPGA with x1 PCIe interface and two 1Gb DDR3 SDRAM devices Shipped with a dual-port 100BASE-T Ethernet module and an I/O expansion module pre-installed 	US\$ 299.95* or ₹ 18,641*
Terasic	Altera DE0 board	 <ul style="list-style-type: none"> Equipped with Altera Cyclone III 3C16 FPGA device, which offers 15,408Les Board includes 346 user I/O pins, one 8Mbyte single data rate synchronous dynamic RAM memory chip, two 40-pin expansion headers, built-in USB blaster circuit 	US\$ 119* Academic: US\$ 81*
Terasic	DE1-SoC board	 <ul style="list-style-type: none"> Built around Altera SoC FPGA, which combines the dual-core ARM Cortex-A9 (HPS), providing 85k programmable logic elements Includes 64MB (32Mx16) SDRAM on FPGA, 1GB (2x256Mx16) DDR3 SDRAM on HPS, serial configuration device EPCS128 on FPGA, onboard USB Blaster II 	US\$ 249* Academic: US\$ 175*

*Prices excluding shipping and other charges

MAJOR CONTRIBUTORS TO THIS STORY



Anoop Jose,
manager - research
and development,
Numato Systems
Pvt Ltd



Bailey Hsu,
director - marketing
division, Terasic



Bryan Fletcher,
global technical
marketing director,
Avnet Electronics



Dhiraj Kumar,
director, Systems
Engineering, Argus
Technologies



Justin Rajewski,
CEO, Embedded
Micro



Mark A. Bowers,
co-founder,
MicroNova
Electronics



Natarajan M.M.,
vice president
for South Asia of
Arrow Asia-Pacific
components
business



Prasad Reddy,
FAE manager,
South Asia Pacific,
Altera



Sachin Gupta,
product marketing
engineer, SoC
product line
marketing,
Microsemi



**Sudharsan
Palanikumar**,
senior analyst,
Femto Logic Design
Pvt Ltd

system on modules (SoMs). For example, our Xilinx Zynq offering includes six different Zynq devices.”

“A development board’s native features can be augmented by expansion boards. It should include some kind of expansion, be it FMC, Digilent-compatible peripheral module (Pmod), or both,” he adds.

Prasad Reddy, FAE manager, South Asia Pacific, Altera, too feels development boards should have features that accelerate the development time by directly using the board for the final application with a whole slew of application-specific daughter cards. He says, “In addition, manufacturers having a large partner network that also provides application-specific daughter cards is an added advantage.”

Resources. The second factor that should be considered is availability of tutorials, reference designs and printed circuit board (PCB) sources. Fletcher informs, “Our development boards come with several tutorials and reference designs based on the latest Xilinx software. PDF copies of all PCB design sources are freely available and the full source may be available through the local Avnet

field application engineers (FAEs).”

After-sales support. The third factor is support, such as online documentation, training and forums. Fletcher says, “These capabilities mean engineers can get the help they need as they are learning new technology and developing their products.” Reddy, too, believes, for users adopting new technology, training would be another important factor to consider before buying a board. He says, “Altera offers in-depth training courses that are instructor-lead or online or virtual-classroom based trainings that would offer in-depth insight into the given technology.”

Cost. Last, the cost of acquisition also matters. Depending on your budget, you must select the right board that meets your requirements.

Buyers should also consider the quality of documentation and support. Documentation plays a major role in improving user experience, feels Sachin Gupta, product marketing engineer, SoC product line marketing, Microsemi. Hence, he says, “A step towards improvement in hardware kits is to improve documentation quality as well.”

There are plenty of offerings out there for FPGA development boards, but surprisingly not all are open and accessible to engineers who want to learn, informs Bowers. He says, “As a student, I was shocked to discover that some major FPGA development board vendors do not include complete schematics of their boards, citing portions of these as proprietary. One vendor did not include any schematics.” He adds, “When we built our Mercury FPGA development

The most important factor when looking for a development board is the tools and support offered. If either is lacking, it will make learning how to use the board so much harder

board, we were happy to provide the complete, unabridged schematics, a reference manual and several reference designs to our users. We have also released the entire source code for our USB programmer application so users can modify and use it for their own purposes.” He firmly believes that FPGA development boards should be as open and friendly as possible.

Make the right choice

Hardware platforms for FPGAs are primarily influenced by system-level requirements of today’s applications’ necessities. Vendors are looking to provide low-cost FPGA development boards especially for academic end users. There is continuous effort to bring down the cost of the boards to increase adaptability, informs Gupta. He says, “Ease of use is being ensured by vendors by improving documentation quality and providing an extensive set of demonstration guides and application notes with the kit, which also help in quick learning.”

There are many FPGA boards available from individual vendors and third-party companies. Users have a choice of buying a kit that meets their requirements for their proof-of-concept before starting development activity on custom boards. ●

Increasing FPGA densities, board interfaces, supported connectors for add-on modules from third-party vendors and built-in joint test action group (JTAG) interfaces are making boards more powerful and capable

This Month's DVD Contents

This month's DVD is a collection of a variety of electronics software, including different circuit simulators and design suites for printed circuit boards (PCBs) along with a technology-focussed computer aided design (CAD) tool. It also contains a Flightgear simulator for fun with learning

SNEHA AMBASTHA

GeckoCIRCUITS

A circuit simulator for modelling power electronics systems, it combines both control modelling and thermal simulations via equivalent networks in an easy-to-use software package. Its strength lies in its extremely high simulation speed and open interface. The software can be integrated into MATLAB/Simulink or other programming environments.

Proteus design suite

Proteus PCB design suite combines all powerful and easy-to-use tools for schematic capture and ARES PCB layout programs to provide a professional PCB design tool. The ARES PCB layout supports up to 16 copper layers, 10nm resolution, full electrical and physical design rule checks, any angle component placement and much more.

DipTrace

DipTrace is a professional PCB design tool for professional designers and electronics engineers. Professionals find its ability to import projects and libraries, such as LT Spice, CAD, Accel, Allegro, Mentor and Protel, very useful. It has a validator that checks if the circuit will actually work in the real world; and if there is an error, DipTrace suggests a way to fix it.

nano-archimedes

nano-archimedes is a technology computer aided design (TCAD) software tool used for the simulation of many technology-relevant situations that involve the dynamics of electrons, like transport in nanometre-scale semiconductor devices and

dynamics of many-body problems in quantum chemistry.

Winlog Lite

Winlog Lite is the entry-level version of supervisory control and data acquisition (SCADA)/human-machine interface (HMI) software, Winlog Pro. It helps evaluate the potentiality and simplicity of Pro tool. Winlog Lite is a low-cost solution for small supervisory applications that provide access to most development tools and functions available in Winlog Pro.

IRSIM

IRSIM is an open source software with an ability to simulate in two different modes: switch and linear. During switch mode, it initialises and determines the functionality of a metal oxide semiconductor (MOS) network, whereas in linear mode, it determines the number of times the gate delays and the circuit transition occurs.

GNU Radio

GNU Radio is a free software development toolkit with signal processing runtime and processing blocks for implementing software radios using the easily available external radio frequency hardware and commodity processors at a low cost. It is widely used in commercial environment to support wireless communications research and to implement real-world radio systems.

Digital Logic Design

Digital Logic Design is a software tool for designing and simulating digital

Popular resources

- 7Zip. Version 9.38 (file archiver)
- Java Runtime Environment. Version 8.0.310.13 (runs programs written in Java programming language)
- VLC. Version 2.1.5 (media player)
- Opera. Version 27.0.1689.76 (web browser)
- Free Download Manager. Version 3.9.4 (file download manager)
- Thunderbird. Version 31.1.0 (email application)
- Mozilla Firefox. Version 36.0 (web browser)
- Apache Open Office. Version 4.1.1 (open office)
- Amiti Antivirus (antivirus)

circuits that provide digital parts ranging from simple gates to the arithmetic logic unit. It allows easy conversion of the circuit into a reusable module, which can further be used to build more complex circuits like a central processing unit. The working circuit can be analysed using output parts like light emitting diodes and 7-segment display.

PCBWeb designer

PCBWeb designer is a free CAD application used for designing and manufacturing electronics hardware. It contains a fully-integrated component catalogue to allow easy search and filter and to place parts that have both symbols and footprints. It has a fast and easy-to-use wiring tool that enables one to design multi-sheet schematics.

JumboCAD EDA

JumboCAD EDA is a package that includes a schematic capture, PCB designer and library editor. The schematic capture allows one to create an electronic diagram and simulate the circuitry, whereas the PCB designer helps build the PCB layout and generate Gerber files for fabrication. ●

The author is a technical journalist at EFY

GNU Radio: An Open Source Software Radio Ecosystem

JAI SACHITH PAUL

We cannot include software defined radios (SDRs) among the latest concepts evolved in wireless communication. Software radios have been present for more than three decades. However, many processes that were considered theoretical are now practically possible with the rapid pace of growth in digital electronics. Interestingly, a lot of people including hobbyists, academicians and working professionals are increasingly becoming interested in exploiting the opportunities rendered by software radios.

In this article we will focus on GNU Radio, a popular software development toolkit consisting of signal-processing blocks for creating SDRs and other signal-processing systems.

The infrastructure of this software is completely written in C language, whereas many user tools are implemented in Python. The latest stable release of this software licensed under GNU general-public licence (GPL) 3 is version 3.7.5.1, and it is included in this month's DVD for EFY Plus.

Smart graphical interface for easy designs

The first question that might arise in your mind if you are not a very good programmer is, "Do I have to sit and type the entire code?" or "Is there a Simulink-like tool that may make my job easier?"

The answer is yes! This software package comes with GNU Radio Companion (GRC), a graphical signal-processing environment for all simulation needs. The GUI will seem simple and straightforward if you

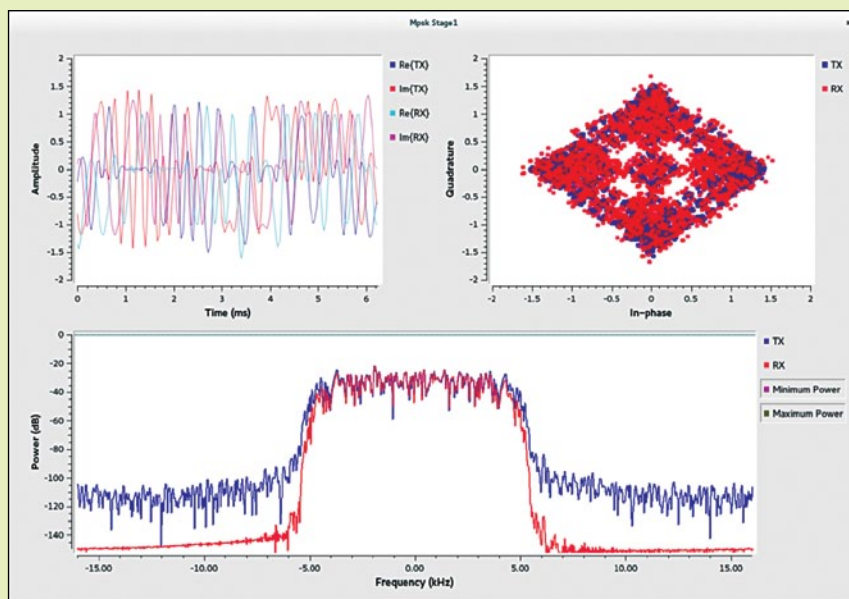


Fig. 1: Plotting demodulated waveform using GNU Radio

Software defined radios

The SDR forum defines these as radios in which some or all physical layer functions are software-defined. The software present in a personal computer or an embedded system can replace hardware components like amplifiers, mixers, modulators/demodulators in a typical radio communication system. Delivery of the final product to the market will be quicker. There will be lesser development costs, minimised maintenance expenses and, ultimately, the end user will get better product at a cheaper rate. Also, since the software is easily replaceable, we can use the same hardware to make different radio systems for various applications.

paid attention in your digital signal-processing classes.

For invoking GRC in Linux, you can call the GRC command. A GRC will pop up on its window and you will have a collection of built-in blocks on the right-hand side of the window to choose from. You can drag these blocks to the main window and connect these by clicking on the edges.

The function of GNU Radio here is to supply you with a multitude of

blocks and execute the flow graphs after their definition. It calls the blocks one after the other, while ensuring that items are passed from one block to another.

How it is different from Simulink

For Simulink users, flow graphs will either run based on frame or on sample. The sample based model is intended to have better control over the signal-processing stream, but in designs that require better

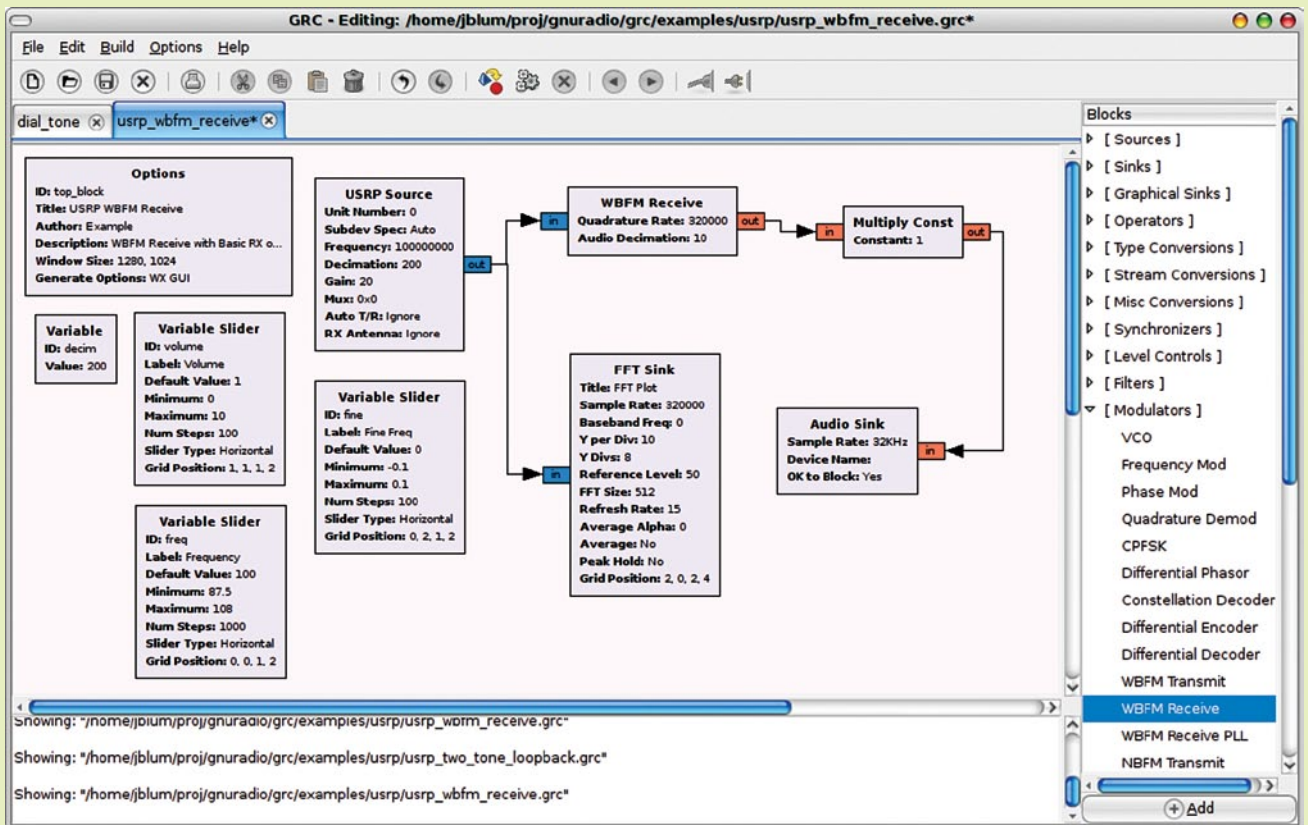


Fig. 2: GNU Radio Companion

Blocks, items and flow graphs

The signal processing takes place inside blocks. Every block has a unique function to perform, which makes the design modular and flexible. Output of the blocks is referred to as an item; an item could be anything with a digital representation.

As in graph theory, the graph through which the data flows is called a flow graph. Blocks are present at the nodes of such graphs and the data flows along the edges of this graph.

performance, frame based processing is often preferred.

In GNU Radio, flow graphs only have item based processing. An item is mostly a sample but could be

a vector too. A logical description of inputs at the input port gives you the item size. In this environment, processing of the maximum possible items takes place every

time the performance of the design is improved.

The downside of GNU Radio approach is that it does not allow introduction of recursive flow graphs.

Creating blocks and extending applications

From being just a beginner to a researcher or professional developing something peculiar, you may feel the lack of certain components. There are also chances that blocks are not

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Included tools and utility programs

The toolkit comes with a large range of built-in tools and programs for the developer. Let us take a look at some of the most commonly used tools.

uhd_fft. By using this simple spectrum analyser tool, we can display the spectrum at a given frequency by connecting a universal software radio peripheral hardware driver (UHD) device. The tool can also be used for a waterfall plot or as an oscilloscope.

uhd_rx_cfile. The function of this tool is to record an I/Q sample stream using a connected UHD device. Samples are written to a file and can be analysed offline at a later time, using either GNU Radio or other tools, such as Octave or MATLAB.

uhd_rx_nogui. This tool receives and listens to incoming signals on your audio device. It can demodulate AM and FM signals.

uhd_siggen{gui}.py. This is a simple signal generator application that can create the most common signals, such as sine, sweep, square and noise.

gr_plot*. This tool contains an entire suite of apps that can display pre-recorded samples saved to a file. The user can plot spectra, PSD and time-domain representations of these signals.

We can call these applications from the command line in Linux. A help switch -h is included with all these applications.

flexible enough for your application. In this case, you may add your own blocks. Building blocks in C++ language ensure that speed and performance are not compromised. But if you want to quickly prototype something without arguing with C++, you can opt for Python.

GNU Radio blocks are also avail-

able in Python, even if these are written in C++. This is made possible with the help of simple wrapper and interference generator (SWIG). Glue codes are automatically generated with the help of this functionality. This is done in order to help users code everything themselves and to enable them to enjoy the power and

flexibility of Python and its libraries for Python-centric processing of signals, or making use of their favourite widget library to create any GUI.

Bringing the code closest to the antenna. The main idea behind the GNU Radio project, as described by project founder Eric Blossom, is to bring the code as close to the antenna as possible and to turn hardware problems into software problems.

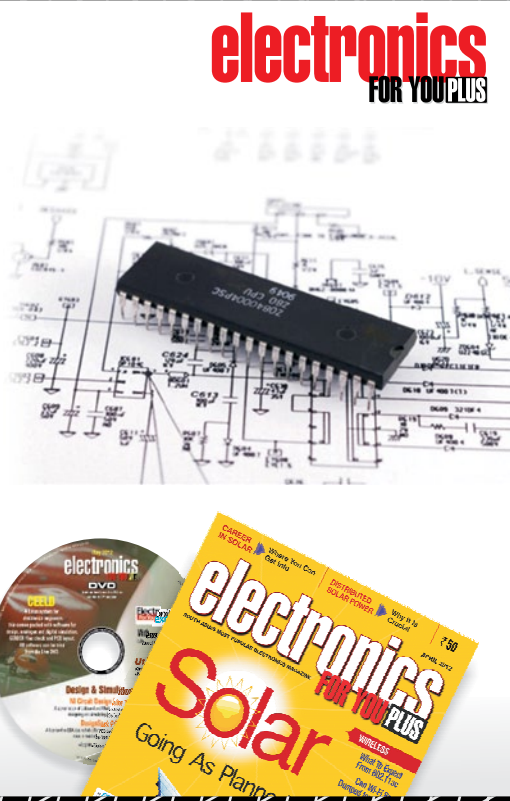
People around the world make use of GNU Radio along with readily-available low-cost external RF hardware to develop real-world SDRs. These are also run without hardware in simulation-like environments. With developments in communication techniques, like orthogonal frequency division multiplexing, the number of users for the tool has been increasing exponentially. Hopefully, in the near future we can expect the vision behind the project to be fulfilled. ●

The author is an electronics enthusiast from Kerala

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IRSIM: A Switch-Level Circuit Simulator

SNEHA AMBASTHA

Regular readers of this section must have seen many circuit simulators by now, but how many of these actually allow us to modify the circuit at the simulation stage? Well, here we have one such simulator, IRSIM. This tool allows us to modify the circuit under simulation and re-simulate it using IRSIM. IRSIM is available for both Linux and Windows operating systems (OSes) in the DVD accompanying this month's issue of EFY Plus.

IRSIM, not the Invisionix Systems' portable instant messenger you get when you Google the term, is an interactive and incremental logic-level simulator used for metal oxide semiconductor (MOS) transistor based digital circuits. Pronounced as *eye-are-sim*, this tool is not an infrared simulator, but is always referred to as a switch-level simulator.

Why switch-level simulator

The open source software IRSIM has the ability to simulate in two modes: switch and linear. During switch mode, it initialises and determines

Quick view

- Version: 9.7.87
- Licence: GNU public licence (GPL)
- Key drawbacks:
 1. Cannot remove or reload a file being simulated
- Key features:
 1. Event-driven circuit simulator
 2. Faster than Spice
 3. Has a built-in display for interactive interactions

Competitors

- ModelSim
- Spectre
- SPICE

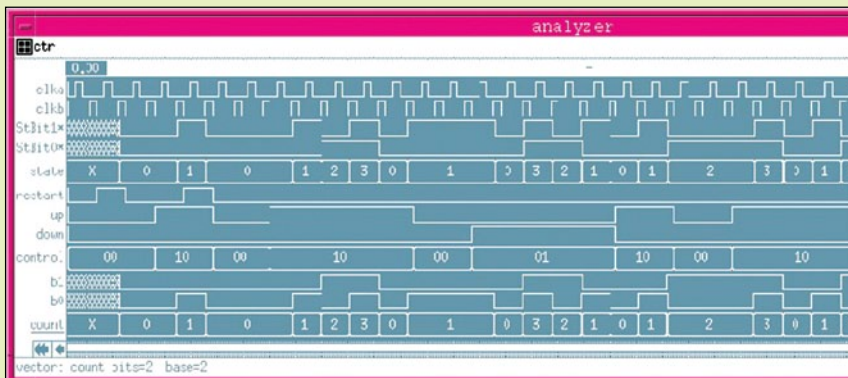


Fig. 1: IRSIM simulation of the 2-bit up-down counter

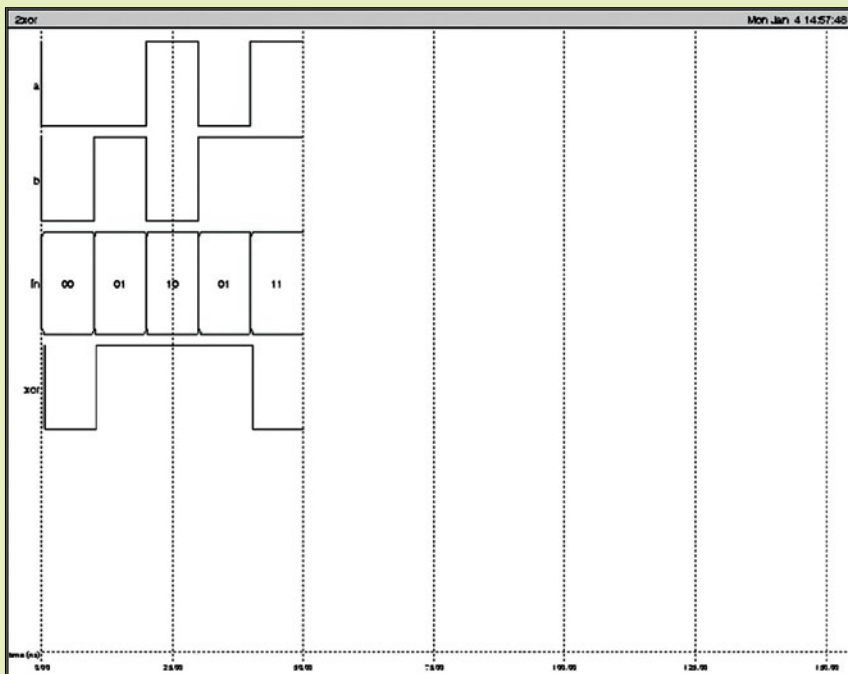


Fig. 2: IRSIM simulation output file created using Print Menu command

the functionality of a MOS network, whereas in case of linear mode, it determines the number of times the gate delays and the circuit transition occurs.

An interesting point to note is that although it has the ability to work in two different modes, we still relate it to only one mode. The reason is that, IRSIM models the circuits at transistor level where these transistors are

modelled as switches. At this point, most analogue and higher order properties of the devices into consideration are ignored and these are treated as ideal on/off connections.

A simulator but not an editor

We are all aware of the importance of a digital circuit simulator and that it needs a netlist to work. A netlist is a circuit schematic with components

and connections created by a circuit editor or circuit design tool. Now, do not confuse IRSIM with a design tool or an editor, as it can simulate but cannot create a netlist. Although it is

an independent tool, it easily accepts a netlist from other tools.

Circuit behaviour and IRSIM

IRSIM being a switch-level simulator

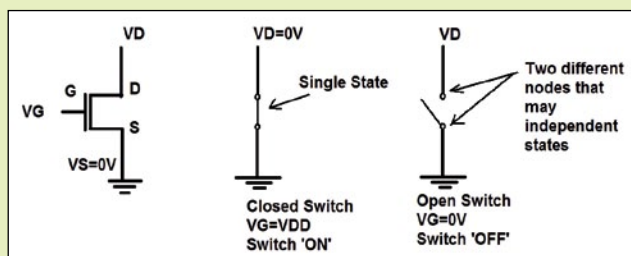


Fig. 3: NMOS transistor acting as a switch

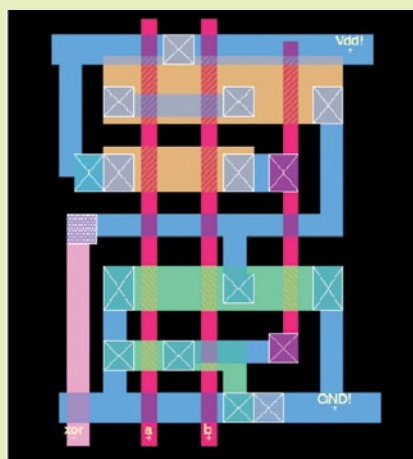


Fig. 4: Layout of 2-input XOR gate

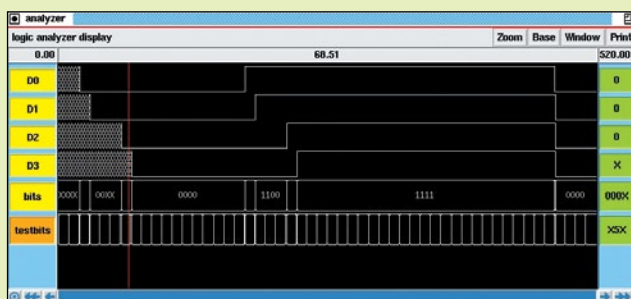


Fig. 5: The analyser graphic display in IRSIM 9.7

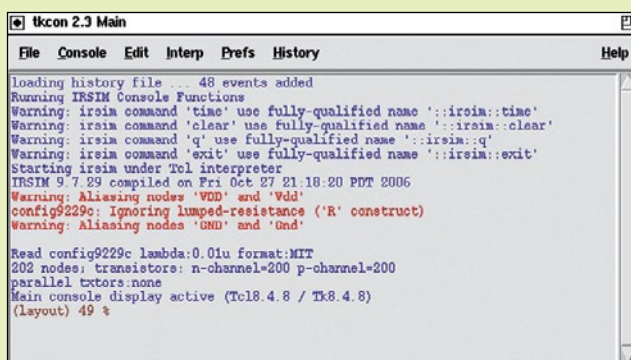


Fig. 6: The IRSIM command console in Tcl or Tk based version 9.7

works on three important aspects of the behaviour of a digital circuit, namely, transistor state, logic value and transition events.

A transistor state is a linear model state, where

each switch has two states: on and off. This linear model helps IRSIM reflect the differences between the different types of transistors, rise and fall times of the gate and different fabrication processes very accurately.

On the other hand, the logic value behaviour of the circuit allows IRSIM to treat voltages in a circuit as three different values, that is, high (h,1), low (l,0) and indeterminate (unknown or x). This way, IRSIM does not have to bother about the actual voltage that is powering the circuit.

The linear model works with these voltage values and helps compute the generation of a normalised (high) voltage.

The above two aspects help us identify the simplified modelling of a circuit using IRSIM. However, on account of transition events, IRSIM treats a circuit as a cascade of events. This makes IRSIM an event-driven simulator. Let us understand how.

All switch-model transistors have a source-to-drain path and a controlling gate

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IRSIM on Windows

Though built specifically for Unix OS due to its graphical environment, IRSIM can still be used on Windows OS. The graphical environment of IRSIM is based on X11, which is Unix based and is not compatible with Windows application programming interface (API). Cygwin, which implements Linux on Windows, allows Unix based files to be compiled and run on Windows easily. The multi-window switch allows Cygwin X11 server to run in the background of Windows desktop, enabling X11 Windows to appear on the desktop.

Pre-requisites of IRSIM

- Tcl script
- Shell script
- IRSIM on Windows has an additional requirement
- Cygwin DLL is 1.7.32

that is either on or off. On occasion when the transistor switch is on, source-to-drain nodes are combined to form a single path that can have only one state.

Whereas, when the transistor switch is off, source-to-drain nodes belong to two different paths and may even have independent states, as shown in Fig. 3. This change in state of a gate is considered to be an event that causes IRSIM to re-evaluate the paths between the source and the drain based on the event.

A completely different simulation experience

Each tool has its own advantage that can tempt you to use it, provided the advantages are known and easy to understand.

Modifies simulation and re-simulates incrementally. IRSIM allows modification and re-simulation of corrected errors along with verification of circuit operation. It also maintains a history of all circuit activity during simulation, depending upon which only the circuit that deviates from the history is re-simulated. The overall time taken for this is proportional to the size of the modification and not to the size of the entire circuit; so the simulation is fast.

In order to explain this better, a program was tested with several corrections to the errors that occurred in the design of the VLSI microprocessor at the IEEE Design Automation Conference. It was found that after

correction, the circuit was incrementally re-simulated 1.6 to 3500 times faster than the simulation of the entire circuit.

Two simulation models. IRSIM has two different simulation models: switch and linear. It is considered to be an event-driven simulator that uses the switch model to simulate the transistor modelled as a voltage-controlled switch. This model is useful for determining and initialising network functionality.

Whereas the other type of circuit that has a transistor modelled as a resistor (R) in series with a voltage-controlled switch and a capacitor (C) at each node uses the linear model of IRSIM. The resulting RC network helps compute transition times and node values.

Uses text editor. It provides an easy-to-use text editor that can be easily converted into a simulation (.sim) file.

Completely different simulation. IRSIM uses two special commands, at and every, that enable an easy translation from a Verilog test bench. This provides a completely different simulation method, first by scheduling and then by running the simulator without any further input. The non-Tcl version of IRSIM can execute only IRSIM commands in this procedure.

IRSIM also helps identify the total number of transistors in a circuit.

Non-realistic simulation

IRSIM has no way to determine the charging and discharging of the circuit at the nodes without information about parasitic capacitances to the substrate, along with drain and source sizes of the MOS transistor. It sets all these to a minimum time

step for fast fabrication of the circuit, but it might not be realistic in most of the cases.

Then there are circuits that hold some value on an electrically-isolated node of the circuit and expect the charge on this node to set a value on a different node through charge sharing. These circuits are dangerous and highly dependent on process parameters. Simulation of such circuits using IRSIM will again be non-realistic, as these will assume the voltages at isolated nodes to be constant.

From users' mouths

One user on <http://opencircuitdesign.com/> likes IRSIM over SPICE because of three important reasons: IRSIM treats transistors as ideal switches; IRSIM, although designed to run in the background, displays information regarding values of signals on VLSI layout; and IRSIM allows quick simulation. The user says, "In my opinion, it is much easier to write complicated test bench simulations using Tcl and IRSIM. I have used IRSIM to validate digital parts of several production chips at MultiGiG, including the simulation of analogue behaviour such as PLL locking."

However, another user at <http://www.edaboard.com/> finds it difficult to identify the input for an inverter circuit using IRSIM.

IRSIM has undergone plenty of revisions to try to be the best in its field, but we all know that nothing in this world is perfect. The current version of this tool does not have any way either to remove or reload a file that is being simulated. So, in case you are simulating a wrong file, you will have to wait till simulation is over.

Thus, although IRSIM is quick, it cannot be used for all types of circuits, as it cannot detect sensitive errors in the circuit. However, if the circuit is detected as error-free, IRSIM can give accurate simulation results. ●

The author is a technical writer at EFY

nano-archimedes: A GNU Package for Nano-World Simulations

JAI SACHITH PAUL

In March issue of EFY Plus we discussed Archimedes, a Monte Carlo simulator for various semiconductor device simulations. In this issue we will talk about nano-archimedes, yet another technology computer aided design (TCAD) software. The tool is based on Wigner equation, a convenient formulation of quantum mechanics in terms of phase-space and two many-body approaches, density functional theory (DFT) and a novel time-dependent *ab-initio* method.

Generally speaking, nano-archimedes can be used for the simulation of various technology-relevant situations that involve dynamics of electrons, such as transport in nanometer-scale semiconductor devices (for example, nanodevices) as well as dynamics of many-body problems in quantum chemistry (for example, molecular electronics).

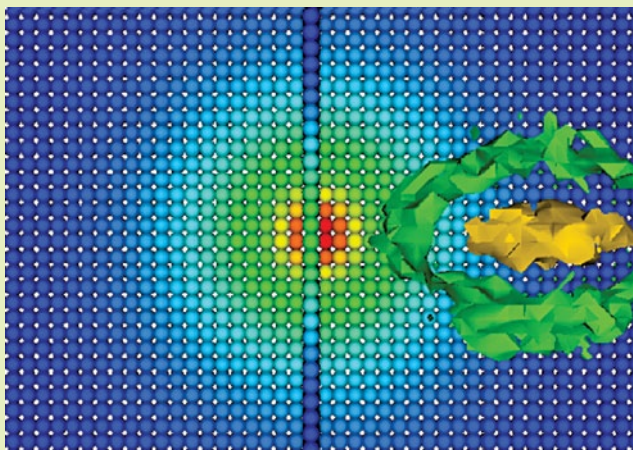
The source code, written in C language, is a truly cross-platform code that can be compiled on a huge variety of machines (serial and parallel) without any particular effort. The first release of the software was made early this year under GPL version 3.

Jean Michel Sellier, the main developer of nano-archimedes, put up every effort to free up more codes on quantum simulations so that a new user could have advanced researches in this area, instead of spending time coding from scratch.

Where nano-archimedes finds its applications

Before going deep into the approaches used for this software, let us take a look at some areas where nano-archimedes could be conveniently used.

Simulating post-CMOS designs. We are now in the so-called post-



Simulation of a wave packet in proximity of Coulombic potential using nano-archimedes

complementary metal oxide semiconductor (CMOS) era. With the continuous process of miniaturisation, the semiconductor's active length has reduced to nanometers. At these scales quantum effects get prominent and the behaviour is quite different from what classical devices (like CMOS transistors) were designed for. Thus we require a new design paradigm that exploits the typical phenomena of quantum mechanics. The gap between theoretical comprehension and rapidly-advancing experiments can be effectively bridged with the help of quantum simulations using this software.

Practical design and optimisation of realistic solotronic devices.

With advances in technology, modern electronics have the capability of manipulating single dopant atoms in semiconductor materials with atomic precision. These advancements took the name and shape as a unique branch of electronics called solotronics. Again, the theoretical comprehension cannot keep in pace with the experimental advancements that would eventually prevent the practical design and optimisation

of solotronic devices. There is an increased demand for TCAD software that would help in a meaningful study of solotronic designs, which require a time-dependent, full quantum, multi-dimensional model, even in the relatively simpler case of ballistic regime. nano-archimedes is a free

open source option that could ideally, and easily, fill up this space.

Simulating chemical systems. Researchers working in applied atomic physics and quantum chemistry try simulating quantum chemical systems like atoms and molecules with the help of quantum mechanical models. For determination of chemical properties of such a system, their electronic structure should be calculated. This involves numerical simulation of the quantum many-body problem, one of the most computationally-demanding and difficult problems in applied physics.

A pseudo-potential model computes the effective potential consisting of a super position of the core electrons and nucleus potentials. This model can thus be used to reduce the original problem to the simulation of valence electrons only. This modelling could be effectively done by Wigner formalism used in this software.

Ab-initio simulations of the quantum many-body problem

The term *ab-initio* simulations refers to simulations based on the first

principles of quantum mechanics. These simulations are considered to be comparatively difficult and drained immense computational resources. Despite this, a lot of research interests exist in this area. Scientists believe that the tools developed on *ab-initio* principles can assist in various ways that can significantly improve various aspects of human life. The tool could make notable contributions, for instance, in the designing of new drugs, new materials and in the development of new information-processing technologies such as quantum computing devices.

nano-archimedes is based on the many-body Wigner equation, a sophisticated (and yet, very intuitive) formalism that allows *ab-initio* (Monte Carlo) simulations in phase-space, even for strongly-correlated systems.

Wigner formalism

Wigner formalism is a time-dependent, full quantum, multi-dimensional model based on the concept of a quasi-distribution function defined in phase-space. The approach is very intuitive and totally equivalent to the well-known Schrödinger model. In this model, an invertible Wigner-Weyl transform exists, which converts wave functions into quasi-distribution functions, and vice-versa. From this angle the situation is not any different from classical mechanics, where different formalisms like Newtonian, Lagrangian and Hamiltonian exist, and can be more or less convenient, depending on the system under consideration.

A system in Wigner formalism is described in terms of a quasi-distribution function defined in the phase-space of n -particles. Hence, we can consider this formalism as a very intuitive approach that is closer to the way experimentalists perform their experiments. Wigner equation allows simulation of many-body quantum systems in a time-dependent, multi-dimensional fashion. This allows scientists to simulate ground and excited states.



nano-archimedes is a very exciting project. There is no doubt that the next-generation technology will be strongly based on our comprehension of quantum mechanics. Our software is the first complete and working, full-quantum, multi-dimensional and time-dependent simulator released under GPL. This means that anyone can use it, modify it and share it. Despite being released only recently, I can already see this code being perceived by the community as a tool on which to construct even more advanced results. I am sure that it represents a concrete advance towards the comprehension and design of practical quantum devices."

— Jean Michel Sellier, main developer of nano-archimedes

The iterative Monte Carlo method—a general time-dependent approach for partial differential equations that can deal with general initial and boundary conditions—is utilised to numerically solve Wigner equation. Monte Carlo techniques scale incredibly well on parallel machines, allowing the simulation of comparatively very complex systems. We have discussed about Monte Carlo simulations in detail in March issue of EFY.

The Wigner formalism is nowadays applied to a plethora of different situations. For example, recently it has been utilised in the field of simulation of semiconductor devices, post-CMOS design and quantum chemistry (Wigner DFT and many-body techniques), among others. nano-archimedes software is based on this Wigner formalism and could be used in advanced research in these areas.

Signed particle formulation to be introduced into nano-archimedes

The latest development in nano-archimedes is based on a brand new formulation of quantum mechanics called signed particle formulation, which is currently under review. This is an important generalisation of Wigner MC method provided with a physical interpretation. In this novel formulation, a quantum system is described in terms of virtual Newtonian field-less particles that can interact with a potential by means of creation and annihilation of particles only.

Being a very intuitive approach, thus easy to implement, the signed particle formulation proves to be more convenient than other approaches in certain cases of quantum system simulations. "Even though the signed particle formulation is mathematically equivalent to other formulations, such as Schrödinger and Wigner, it has strong advantages to be intuitive, highly parallelisable and easy to extend to situations such as inelastic scattering," says J.M. Sellier.

Boosting up scientific innovations

In the initial days of research, there are times when we do not know where to start the work. If we consider the semiconductor industry, researches around the world have been so advanced that we are now dealing in nano-scale sizes. Unfortunately, the people who are new to this field of research have to begin their work from scratch, as every work will be patented and not available freely. This will waste a lot of time, effort and money.

Providing the source codes of Archimedes and nano-archimedes as open source is a positive step in this regard, as more researchers could benefit from it and could spend their time more fruitfully. Let us hope this step from the developers will inspire other researchers to release more free scientific codes, and thereby enhance more scientific advancements in the society. ●

The author is an electronics enthusiast from Kerala

Part 3 of 4

Precision-Guided Munitions: Infra-Red-Guided Weapons



Dr Anil Kumar Maini is former director, Laser Science and Technology Centre, a premier laser and optoelectronics research and development laboratory of Defence Research and Development Organisation of Ministry of Defence



Nakul Maini is currently pursuing Masters at University of Bristol, UK. He was working as a technical editor with Wiley India Pvt Ltd

Infra-red-guided [(IR)-guided]] weapons are no less important than laser-guided munitions considering their usage in tactical warfare. While laser-guided munitions are predominantly used in air-to-surface and surface-to-surface roles, IR-guided weapons are largely surface-to-air man-portable air defence systems (MANPADSs) and air-to-air missiles. The IR-guided air-to-air missile has been a feature of the fighter armament since 1950's and is likely to remain a key weapon for decades to come.

While laser and radar-guided weapons use semi-active or active homing for guidance, and therefore need an external laser source or radar for the purpose, IR-guided weapons make use of passive homing guidance in which the weapon homes on to the IR signatures due to hot areas of the target. For this reason, these are popularly known as heat-seeking weapons. Of course, for the weapon to be reliable, the guidance system processor has to perform the complex task of detecting and identifying the genuine signal in the presence of noise produced by unwanted IR emissions from

the background due to reflection of solar radiation from the Earth's surface, clouds and mountains, and IR countermeasures such as chaff and flares deployed by the target.

Initial development of IR-guided (or heat-seeking) missiles began in late 1950's. AIM-4 Falcons and AIM-9 Sidewinders are important air-to-air heat-seeking missiles of that time. These weapons were not very successful, initially, due to certain issues that were mainly related to reliability. Modern IR-guided missiles are a vast improvement over the ones developed in yesteryears. These not only have increased operational ranges and hit accuracy, these are far less vulnerable to countermeasures and are capable of discriminating the intended target from passive and active countermeasures.

IR homing guidance

There are two broad categories of IR-guided weapons, namely, those employing non-imaging-type IR-seeker heads and those employing imaging infra-red (IIR) seekers. Non-IIR-guided missiles home on to IR signatures produced by hot areas of the target. Fig. 1 shows hot spots on the target aircraft as seen by the seeker head of an IR-guided missile.

Fig. 2 shows different sources of IR signatures of the aircraft. The IR sensor used in this case is a single detector. In the case of IIR seekers, it is an imaging IR sensor, which is a focal plane array of IR/UV detectors. Imaging sensor array sees in IR in a manner similar to the functioning of a CCD sensor in a webcam or a digital camera.

IIR sensor output requires much more complex signal processing. In addition to being more resistant to IR countermeasures, such as flares and decoys, imaging seekers are also less likely to be fooled into locking onto the sun, another common trick for avoiding heat-seeking missiles. By using advanced image processing tech-

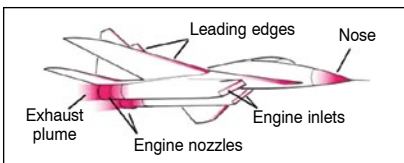


Fig. 1: Hot spots on the target aircraft as seen by an IR seeker

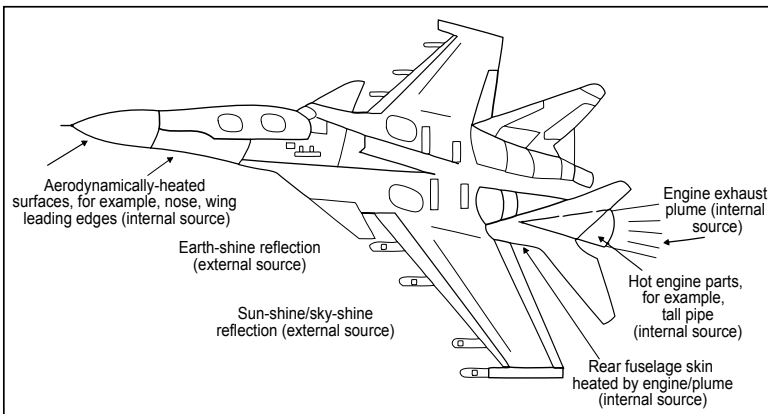


Fig. 2: Sources of IR signatures

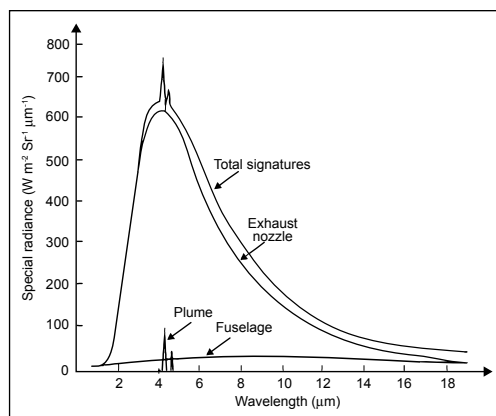


Fig. 3: Spectral profile of an IR emission from a typical target aircraft

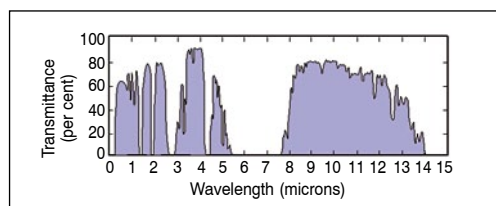


Fig. 4: Transmission characteristics of the atmosphere

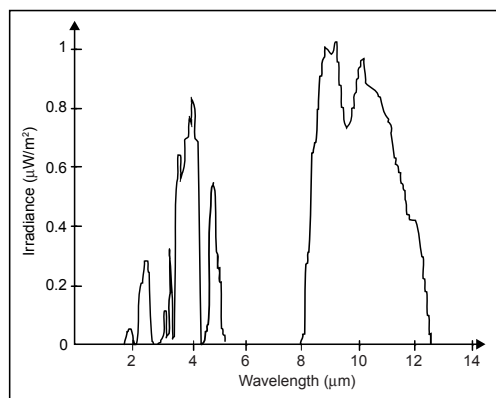


Fig. 5: IR spectrum as seen by the seeker head of an IR-guided missile

niques, the target shape can be used to find its most vulnerable part. This information can then be used to steer the weapon towards the target.

Non-IIR-guided missiles make use of IR emission corresponding to thermal signatures of the exhaust and the mainframe of the target aircraft to home on it. Emission in 3-5 and 8-12 micron bands is characteristic of electromagnetic emission from jet exhaust and mainframe of the aircraft. Fig. 3 shows the spectral profile of IR emission from different parts of a typical target aircraft. Spectral content of IR emission as received

by a seeker head is the superposition of spectral emission of the aircraft on the transmission characteristics of the atmosphere (Fig. 4).

Fig. 5 shows a typical IR-emission spectrum that would be seen by the non-imaging seeker head. This wavelength signature is judiciously used in guidance of air-to-air and surface-to-air IR-guided missiles.

Modern IR seekers also operate in the 8-12 micrometre wavelength range, which is absorbed least by the atmosphere. Such seekers are called two-colour systems. Two-colour seekers are harder to defeat with countermeasures such as flares and jammers.

IR-guided missiles developed in 1970s and 1980s used single-colour IR seekers employing 3-5 micron band. IR seekers used in these missiles were most effective in detecting IR radiation of shorter wavelengths such as 4.2 micron emission of carbon dioxide efflux of a jet engine. Seekers responding to 3-5 micron band were called single-colour seekers and missiles as single-colour missiles.

MAGIC series air-to-air missiles from France and R-73 air-to-air missiles from Russia are some examples. State-of-the-art IR-guided missiles use seekers that respond to both 3-5 and 8-12 micron bands to offer improved false alarm rejection and immunity to deception by flares. These seekers are called two-colour seekers and missiles, two-colour missiles. Python from Israel and RVVAE from Russia are examples of missiles using two-colour seeker heads.

Also, both surface-to-air and air-to-air IR-guided missiles receive target's IR signatures in the presence of background radiation from the sky and also IR signatures of flares, if any, deployed by the target aircraft platform. The seeker head should be able to discriminate between IR signatures

of the background and flares from those of the target.

Advantages and limitations

IR-guided missiles and radar-guided missiles are deployed in similar roles, predominantly as surface-to-air and air-to-air guided weapons. It would therefore be nothing but logical to compare the two types of guided weapons.

IR-guided missiles offer several advantages over radar-guided missiles. One, IR-guided missiles are far more immune to electronic countermeasures than their radar counterparts.

Two, IR-guided missiles offer greater safety of pilots of the aircraft carrying these weapons. Due to the inherent fire-and-forget capabilities of IR-guided missiles, after releasing the missile, the pilot can leave the area while the missile guides itself to the target.

Three, IR-guided missiles are almost impossible to detect during launch preparation. On the other hand, radar-guided missiles employ either beam rider or semi-active or active guidance. In all forms, it employs a radar, which can be detected through radar emission during launch preparation or flight.

Four, IR-guided missiles are manoeuvring missiles and are particularly suitable for close engagement.

Five, IR sensors perform well during day and night conditions.

Six, IR sensors employed by heat-seeking missiles cost less per unit.

While radar-guided missiles are all-weather weapons and have relatively much longer operational ranges, heat-seeking missiles perform better in close-in ranges. Also, heat-seeking missiles are vulnerable to the use of passive and active IR countermeasures. Use of chaff, decoys and flares to deceive heat-seeking missiles is a common occurrence. Heat-seeking missiles employing IIR seekers though are far less vulnerable to these countermeasures.

In the early days of development of heat-seeking missiles, these missiles could only lock on to intense sources of heat such as jet exhaust pipes, and therefore could be fired only from be-

hind the aircraft. Present-day missiles using advanced IR sensors can even lock on to friction-heated air streaming back from the aircraft's nose. These missiles can be fired from any angle.

IR-guided-missile seekers

Two broad categories of seekers are used in heat-seeking missiles. These are reticle seekers using single IR detectors and imaging seekers that use a focal plane array of IR/UV detectors. Both types have different variants.

In the most basic reticle seeker (Fig. 6), IR energy emitted by the target is collected by the optical system

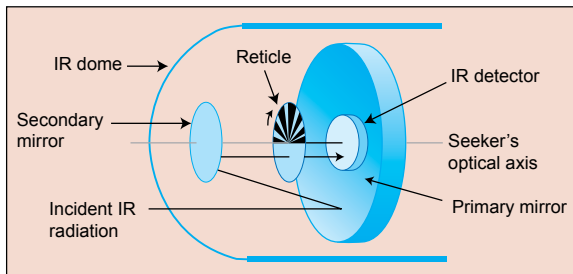


Fig. 6: Basic reticle seeker

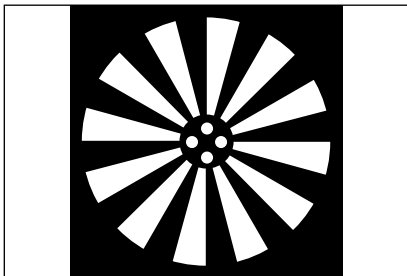


Fig. 7: Representative reticles

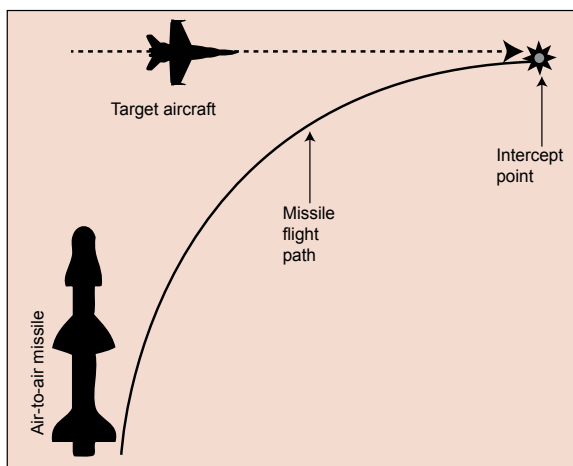


Fig. 8: Pure pursuit navigation

and focused on the detector through a rotating reticle. A reticle is nothing but an optical modulator made up of a circular element having sequentially-arranged transparent and opaque spokes on it (Fig. 7). The reticle chops the scene represented by IR energy. The output of the detector is a sequence of pulses whose amplitude is proportional to the magnitude of IR energy and whose frequency is equal to the product of spin rate of the reticle and the number of transparent/opaque spoke pairs.

Also, modern reticle-seeker based heat-seeking missiles use spinning mirrors and a fixed reticle. The phase of detector signal with respect to a reference phase is used to determine the angular position of the seeker axis with respect to the target. The angular error is then used to keep the seeker axis pointed towards the target within its field-of-view and also control the flight path of the missile to intercept the target.

We have spin-scan seekers that suffer from the problem of centre-null and conical-scan seekers that eliminate this problem. We shall not go into details of these techniques. Lead-sulphide (PbS) with peak sensitivity in the wavelength region of two micron when uncooled, indium-antimonide (InSb) with peak sensitivity in 4-5 micron band when cooled to liquid nitrogen temperature and mercury-cadmium-telluride (HgCdTe) with peak sensitivity in 8-12 micron band when cooled to liquid nitrogen temperature are the commonly used detector materials.

Lead sulphide detectors were used in older missile seekers, which forced missiles to look at stern engagements

as the missile had to look at the hot turbine in the tail-pipe region to get sufficient signal to track the target. Modern missiles almost invariably use InSb or HgCdTe detectors.

Missile seekers would find it very easy and convenient to detect and track a hot target against a uniform benign cool background than doing so in the presence of clouds and extended IR sources. Sunlight reflected from the edge of a cloud would be as attractive a target, if not more, for the missile seeker than a jet aircraft. Reticle seekers handle all these issues by having very small instantaneous field-of-view (IFOV) and/or advanced signal processing.

Navigation to the target is the next important step after target acquisition and tracking. In one method called pure pursuit, also called direct pursuit, the navigation technique ensures that the seeker is looking at the target continuously throughout the engagement duration till it eventually hits the target. In the case of pure pursuit engagement, the flight path is not the most direct one, as shown in Fig. 8, and the trajectory has an ever-decreasing radius-turn towards the end of the engagement. This poses a problem as the missile may not be left with enough energy to complete the turn in close-in range, allowing the target to escape.

Proportional navigation or proportional pursuit, which is invariably followed in air-to-air missiles, allows the missile to have the shortest flight path towards the intercept, and therefore eliminates the need for a high-g manoeuvre towards the end. Proportional navigation flight path is established by a constant look angle as shown in Fig. 9 for a given constant missile velocity and assuming that target does not manoeuvre. In practice, target does manoeuvre and the missile velocity is also not constant through engagement duration. Therefore look angle is updated as and when required.

A variant of the reticle seeker is the pseudo imaging seeker. This seeker uses one or more detectors enabling both spatial and temporal infor-

mation from reticle seekers. A small IFOV (\cong two milliradian) is scanned in a preset pattern and spatial information is used to determine the time instant of appearance of the target within the field-of-view. Detectors are therefore activated only within the time gate around the predicted time. This allows the missile to avoid large clutter and false targets outside the time gate. It also makes seeker highly immune to IR countermeasures.

Imaging seekers use an array of detectors called imaging focal plane

arrays (Fig. 10) instead of reticles to build an image of the scene in front (Fig. 11). The image may be created by scanning the scene and using a linear array or a two-dimensional staring array. Imaging seekers are very expensive, require huge processing power and complex tracking algorithms. These are therefore employed only under demanding operational requirements. Reticle seekers, on the other hand, are less expensive and easy to manufacture and operate, and have a proven reliability and accuracy.

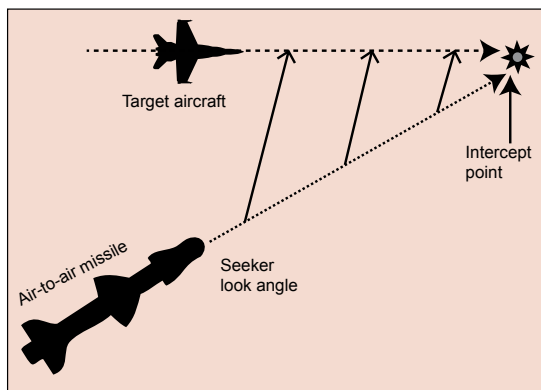


Fig. 9: Proportional navigation



Fig. 10: Imaging focal plane arrays

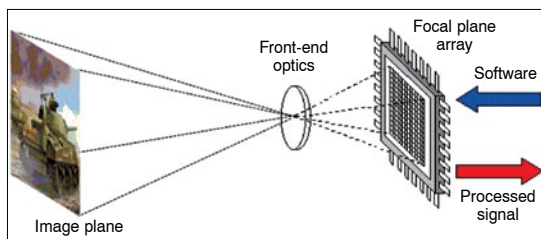


Fig. 11: Imaging IR seeker concept



Fig. 12: FGM-148 Javelin

IR-guided missile systems

Some of the better known IR-guided missile systems are briefly described in the following paragraphs. These missile systems have been grouped into three categories, namely, anti-tank-guided missiles (AT-GMs), surface-to-air missiles (SAMs) and air-to-air missiles (AAMs).

Anti-tank-guided missiles. ATGMs, also known as anti-armour missiles or anti-tank missiles, are designed to precisely hit and destroy heavily-armoured military vehicles including all combat and transportation vehicles. Different variants of anti-tank missile systems include shoulder-fired weapons, large-tripod-mounted weapons, vehicle-mounted weapons and systems launched from airborne launchers. American Javelin, German PARS-3 LR, Israeli Spike and Indian Nag are some examples.

American FGM-148 Javelin (Fig. 12) is a man-portable third-generation fire-and-forget anti-tank-guided missile jointly developed by Raytheon and Lockheed Martin. It has an effective firing

range of 75m to 2500m, with 4750m being the maximum range. It uses a tandem-shaped charge warhead that can penetrate reactive armour. The missile can be used in both top attack mode to hit usually thin-top armour of the target vehicle and direct mode to hit buildings and airborne targets. It uses an IIR seeker and on-board tracker to make it a fire-and-forget missile. It was introduced into service in 1996 and is in service till date. It was successfully used in Operation Enduring Freedom (war in Afghanistan) and Operation Iraqi Freedom.

PARS 3 LR (Fig. 13) is an autonomous fire-and-forget missile intended for long-range applications and designed to destroy ground (tanks and armoured vehicles), air (helicopters) and other individual targets. Manufactured by Parsys GmbH, MBDA Deutschland GmbH and Diehl BGT Defence, PARS 3 LR is also known as TRIGAT-LR and AC-3G. The missile can be launched from a ground vehicle or a helicopter and can be fired in salvos of up to four missiles in eight seconds. The missile has a specified operational range of 500m to 5000m, which is extendible up to 7000m. It can be used in both top (terminal dive) mode as well as direct mode. Fig. 14 (top part) shows the flight trajectory for top-attack mode employed for anti-armour role with the missile launched from either a land vehicle or a helicopter.

It also shows the flight trajectory for direct-attack mode (bottom part) employed for an anti-helicopter role with the missile launched from either a land vehicle or a helicopter. The missile uses a passive IR seeker that locks on to the target before the missile is fired. It uses tandem-shaped charge for maximum lethality against modern reactive armour. German army has authorised series production of the missile system. The delivery began in mid-2013 and shall continue till 2016.

Spike is a fourth-generation man-portable fire-and-forget anti-tank and anti-personnel missile designed and developed by Rafael Advanced Defence Systems. The missile can be



Fig. 13: PARS 3 LR

launched in fire-and-forget mode, destroying targets within the line-of-sight of the launcher and also in fire, observe and update guidance mode while following a top-attack flight trajectory.

In fire-and-forget mode, the tracker is locked on to the target. The missile is launched and it automatically propels itself towards the target. The missile uses a tandem-charged high explosive anti-tank (HEAT) warhead that can penetrate explosive reactive armour.

The guidance system of Spike comprises a charge-coupled device (CCD) and an IIR seeker. The IIR sensor, in addition to providing higher sensitivity, offers improved thermal background rejection characteristics for all-weather day and night operation.

Different variants of Spike missile system include Spike short range (Spike SR) with a maximum opera-

tional range of 800m, Spike medium range (Spike MR) with maximum operational range of 2500m, Spike long range (Spike LR) with maximum operational range of 4000m, Spike extended range (Spike ER) with maximum operational range of 8000m, Spike non line-of-sight (Spike NLOS) with maximum operational range of 25km and Mini Spike with engagement range of 1300m. Mini Spike is an anti-personnel-guided weapon.

The Spike missile system is currently in service with Dutch, Chilean, Colombian, Finnish, German, Polish, Italian, Peruvian, Spanish and Singaporean armed forces. The missile system has been successfully used during Lebanon war in 1982, Second Intifada beginning year 2000, Afghanistan war from 2001 till date and Iraq war in 2006.

Nag (Fig. 15) is a third-generation fire-and-forget ATGM from India, designed and developed by Defence Research and Development Organisation (DRDO) and manufactured by Bharat Dynamics Ltd. It has two variants employing an active IIR seeker and a millimetric wave seeker. The operational range for the land version is 500m to 4000m, and 7km to 10km for air-launched version. It is likely to be inducted into service in 2015.

Surface-to-air (SAM) missiles. Short- to medium-range missiles used in the air defence role against attack helicopters and aircraft are the most common surface-to-air missiles

that use IR homing guidance. A large proportion of these missiles belong to the category of MANPADS. Some of the more common and better known IR-guided surface-to-air missile systems are Stinger, Igla (Igla and Igla-1) and Strela (Strela-2 and Strela-3).

FIM-92 Stinger is a man-portable IR-guided surface-to-air missile designed by General Dynamics and manufactured by Raytheon Missile Systems in the USA, in Germany by European Aeronautic Defence and Space Co. (EADS) and in Turkey by ROCKETSAN. It entered into service in 1981 and continues to be in service till date. It is adaptable to be shoulder fired [Fig. 16(a)] or from land vehicles [Fig. 16(b)] as surface-to-air missile and helicopters as air-to-air missile. Stinger missile has evolved over the years and has undergone significant technological improvements.

Three main variants of stinger include FIM-92A, FIM-92B and FIM-92C. These are known by the names of Stinger basic (FIM-92A), Stinger passive optical seeker technique or Stinger POST (FIM-92B)], and Stinger reprogrammable microprocessor or Stinger RMP (FIM-92C).

Stinger is intended to fulfil short-range air defence (SHORAD) role till 2018. It consists of a Stinger round encased in a launch tube and separates a grip-stock assembly. Stinger basic employs an IR seeker. Stinger POST uses a dual IR and UV seeker, thereby providing higher immunity to countermeasures as compared to Stinger. Stinger RMP is so-called because of its ability to load a new set of software via an ROM chip inserted in the grip at the depot. The missile has maximum effective firing range of 4.8km and maximum speed of 2.2Mach (750m/s).

Stinger made its debut in warfare in 1982 during Falklands war between the UK and Argentina. Subsequently, it was used in the Soviet War in Afghanistan, Angolan civil war, Libyan invasion of Chad, Chechen War, Sri Lankan civil war and Syrian civil war.

Russian Igla is a MANPADS man-

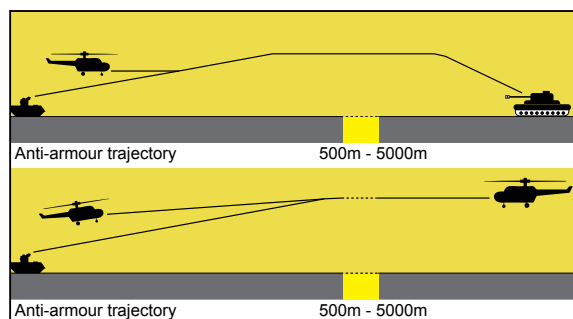


Fig. 14: Flight trajectory in top-attack (top) and direct-attack (bottom) modes



Fig. 15: NAG ATGM



Fig. 16: Stinger missile system being fired (a) from shoulder, and (b) from a land vehicle

ufactured by KBM. The missile has a maximum operational range of 5.2km and a peak speed of 800m/s. It has three variants, namely, 9K310 Igla-1E (NATO designation SA-16 Gimlet), 9K38 Igla (NATO designation SA-18 Grouse) and 9K 338 Igla-S (NATO SA-24). Igla missile system was inducted into service in 1981, and its different variants developed over the years continue to be in service till date.

9K310 Igla-1 with its 9M313 missile uses liquid nitrogen cooled indium-antimonide IR seeker head. 9K38 Igla with its 9M39 missile was inducted into service in 1983. It used liquid nitrogen cooled indium-antimonide and uncooled lead-sulphide IR seeker head that has higher sensitivity and improved resistance to countermeasures and jamming.

Igla-S (SA-24 Grinch) shown in Fig. 17 is the latest generation of portable air defence missile system designed to target visible aerial platforms, such as helicopters, tactical aircraft, unmanned aerial vehicles and cruise missiles. It is an improvement over earlier SA-16 and SA-18 versions. It employs a dual-band IR seeker and has a maximum engagement range of 6km as compared to 5.2km in the case of SA-16 and SA-18. It also uses a heavier warhead, which allows it to destroy the target even if it misses the target by 1.5m.

Strela family of missiles is man-portable surface-to-air missiles that use passive IR homing guidance and a high explosive warhead. Different members of the family are 9K31 Strela-1, 9K32 Strela-2, 9K34 Strela-3 and 9K37 Strela-10. Strela-1 is commonly known by its NATO designation SA-9 Gaskin and is a short-range, low-altitude, self-propelled SAM-carrying system based on the BRDM-2 chassis, an amphibious patrol car mounting two pairs of ready-to-fire 9M31 missiles. The missile has a maximum operational range of 4.2km and speed of 1.8Mach. It uses a lead-sulphide IR seeker.

9K32 Strela-2 (NATO designation SA-7 Grail) is a man-portable, should-



Fig. 17: 9K 338 Igla-S (SA-24 Grinch) missile system

der-fired, low-altitude surface-to-air missile system with maximum firing range of 3700m (Strela-2) and 4200m (Strela-2M). It was inducted into service in 1968. SA-7 Grail is a tail-chase missile system whose efficacy depends on its ability to lock onto the heat source of low-flying fixed and rotary-wing aircraft. The simple IR seeker mechanism of the missile is easily prone to simple countermeasures and environmental effects.

9K34 Strela-3 (NATO designation SA-14 Gremlin) was developed to overcome the shortcomings of its predecessor Strela-2. 9M36-1 missile of SA-14 Gremlin used a new IR homing seeker that was less vulnerable to jamming and decoy flares as compared to SA-7 Grail. It has a maximum operational range of 4.5km and average supersonic speed of 410m/s.

9K35 Strela-10 (NATO designation SA-13 Gopher) was designed to replace Strela-1. It was an improvement on Strela-1 and had an effective firing range of 5km. The 9M37 missiles of Strela-10 used a higher quality IR seeker than was used in 9M31 missiles of Strela-1 system.

Air-to-air missiles. Air-to-air missiles are broadly grouped as short-range air-to-air missiles (SRAAM), also sometimes known as within-visual-range air-to-air missiles (WVRAAM) or dogfight missiles, and medium-range air-to-air missiles (MRAAM) and long-range air-to-air missiles (LRAAM). The second group of missiles is also known as beyond-visual-range air-to-air missiles (BVRAAM).

While missiles of the first group

that have engagement ranges up to 30km are usually heat-seeking missiles, missiles of the second group largely employ radar guidance. In the case of long-range missiles, IR signatures of the target aircraft would be too weak for the detector to be able to track the target. The short-range IR-guided air-to-air missiles have seen five generations of development. These developments have mainly been in IR seeker technologies and to some extent in digital signal processing.

The first generation of these missiles used IR seekers that had a field-of-view of 30° and the attack aircraft needed to position themselves behind the target aircraft during attack. The target in that case could easily move out of the seeker's field-of-view with a simple manoeuvre. Second-generation missiles used IR seekers with field-of-view of 45°. Third-generation missiles were all-aspect missiles, which meant that, the attack aircraft did not have to position itself behind the target aircraft.

Fourth-generation missiles used advanced seekers that had higher resistance to IR countermeasures and increased field-of-view of 120°, giving these higher off-bore sight capability of 60°. Fifth-generation missiles used IIR seekers and more powerful digital signal processing, which gave these higher immunity to IR countermeasures like flares, greater sensitivity and ability to hit vulnerable points on the target.

Some of the well-known contemporary air-to-air missiles include IRIS-T of Germany, Vympel R-73 of Russia, MBDA MICA-IR of France, AIM-132 ASRAAM of Great Britain, AIM-9X Sidewinder and Python-5 of Israel.

IRIS-T is a short-range air-to-air missile manufactured by Diehl BGT Defence. It employs an IIR seeker. It has a maximum speed of 3Mach and operational range of approximately 25km. It was developed to replace AIM-9 Sidewinder missile. IRIS-T has a higher resistance to IR coun-

termesures such as flares. Extreme close-in agility of IRIS-T with capability to make 60g turns at 60°/s allows the missile to engage targets even behind the launching aircraft. It was inducted into service in 2005.

Vympel R-73 (NATO designation AA-11 Archer), manufactured by Tbilisi Aircraft Manufacturing, is also a short-range air-to-air missile with maximum speed of 2.5Mach and maximum operational range of 20km (R-73E), 30km (R-73M1) and 40km (R-73M2). It employs a cryogenically-cooled all-aspect IR homing seeker with high off-bore sight capability, allowing the missile to see 40° off the missile's centre line. It was inducted into service in 1982. R-73 is also on the inventory of Indian Air Force.

MICA-IR (Fig. 18), manufactured by MBDA, is a short- and medium-range air-to-air missile having a maximum operational range of 50km and a maximum speed of 3Mach. It uses an IIR seeker that gives the missile high resistance to countermeasures such as chaff and decoy flares. It can lock on after launch, which means that it can engage targets outside the missile's acquisition range at the time of launch. It is in service since 2000. Indian Air Force has ordered Mica-IR missiles for its MIRAGE upgrade 2000H multi-role fighters.

AIM-132 ASRAAM is a short-range air-to-air missile manufactured by MBDA. It uses an IIR seeker with lock-on after launch capability, has a maximum speed of 3 + Mach and maximum operational range of 50km. It is in use in Royal Air Force and Royal Australian Air Force having replaced AIM-9 Sidewinder. Indian Air Force is also acquiring ASRAAM to replace the ageing Matra Magic missiles. These missiles will be integrated on Jaguar strike aircraft.

AIM-9X (Fig. 19) is the latest addition to the Sidewinder family of short-range air-to-air missiles developed by Raytheon Co. It features an IIR seeker focal plane array seeker with off-bore sight capability of 90°. The IIR seeker gives it higher



Fig. 18: MICA-IR air-to-air missile



Fig. 19: AIM-9X air-to-air missile

resistance to IR countermeasures. The first Sidewinder missile was developed in the 1950s. AIM-9X is the fifth-generation Sidewinder and is now in production. AIM-9X uses passive IR energy emitted by target aircraft for acquisition and tracking, which provides a launch-and-leave air combat missile capability. AIM-9X Sidewinder is characterised by an operational range of about 35km and a speed of 2.5Mach.

AIM-9X Block-I was the first in the family of these missiles. Currently, AIM-9X Block-II has entered full-scale production. Block-II missiles are the upgraded version of Block-I missiles with lock-on-after-launch being the main added feature. The development work has commenced on AIM-9X Block-III missiles. Block-III missiles will have 60 per cent longer range and use insensitive munitions warhead for increased ground crew safety in addition to replacing old components with state-of-the-art ones. Block-III Sidewinder missiles are expected to achieve operational capability by 2022.

Python-5 is one of the most advanced air-to-air missiles in the world. Different variants of Python family include Shafrir-1, Shafrir-2, Python-3, Python-4 and Python-5.

Python-5 is the latest addition to the family and is the fifth-generation

air-to-air missile. Manufactured by Rafael Advanced Defence Systems in Israel, it has many advanced features such as an IIR seeker to give it high immunity to IR countermeasure, target lock-on before and after launch capability to engage targets beyond visual range, higher kill probability and revolutionary full-sphere-launch envelope from very short to beyond visual ranges. It can lock on to the target after launch even when the target is 100° off the bore sight. The missile has an operational range of more than 20km and a speed of 4Mach.

Modern IR-guided missiles using IIR seekers with advanced digital signal processing techniques have much wider detection angles, giving them the capability to launch missiles from large off-bore sight angles. Helmet-mounted sights with pilots of the launch aircraft allow them to distinguish between the target aircraft and a point source of intense heat, such as a flare. These missiles almost invariably have lock-on-after-launch feature, enabling them to engage targets from a very small range to beyond the visual range.

Another recent advancement in missile guidance is the use of electro-optical imaging. The electro-optical seeker scans the designated area for targets via optical imaging. Once the target is acquired, the missile locks-on to it for the kill. Electro-optical seekers can be programmed to hit the designated spot on the target aircraft. The designated spot could be the most vulnerable point of the target. Since electro-optical imaging does not depend on the target aircraft's heat signature, it can be used against low-heat targets such as unmanned aerial vehicles and cruise missiles.

There have been advances in control systems for better manoeuvrability of the flight path. Crew safety on ground has been another concern and it has led to the development of insensitive munitions warheads that do not detonate accidentally.

To be concluded next month



SUNIT RIKHI
VICE PRESIDENT OF THE TECHNOLOGY
AND MANUFACTURING GROUP AND
GENERAL MANAGER OF INTEL CUSTOM
FOUNDRY, INTEL CORP.

“We are running in fog and it is getting denser”

In this interview, we take a look at the integration trends in electronics, how fab technology is evolving and if Moore's law will hit a wall at all. Sunit Rikhi, vice president of the technology and manufacturing group and general manager of Intel Custom Foundry, Intel Corp., speaks with Dilin Anand of EFY

Q. The Internet of Things (IoT) buzzword is widely used these days. But fab has had its equivalent almost two decades ago. What is the long-term effect the IoT has had on electronics?

A. The IoT as a term represents all smart devices that will drive the growing Internet usage in a connected world. As for fab, technologies have existed for quite some time to enable the increasing integration of systems on chips (SoCs) that fuel devices everywhere.

This increasing trend has been with us forever. It was there when Intel introduced the 4004 processor with 2000 transistors on a chip, when it introduced the 80386 processor with over 275,000 transistors on a chip and it is here when processors carry billions of transistors on a board.

In recent times, we have started putting not just processors but systems on a chip, which means integrating diverse circuits on a single piece of silicon and sometimes in a single package with multiple pieces of silicon.

Q. Did this trend have an impact on the fab side of things?

A. From the fab technology point of view, the biggest change brought about is that of going from a processing unit to a system. So, in order to support a central processing unit (CPU), we would need a limited set of functionality and limited scope of envelope of technology capability.

For example, you have digital devices to support a CPU, while to support an SoC, you have to have more than just digital devices. You would need input/output (I/O) devices, radio frequency devices for communication and other components. So it is the SoC technology that has come up as a result.

Q. You get to play with the latest process technologies before most of us even become aware of their existence. What is cutting edge according to you?

A. A few years ago, I met this gentleman at a conference who explained how he was at 130nm node and had heard a lot about 90nm node with its cutting-edge technology. And I was sitting there about to announce the 32nm node, three generations ahead of what this gentleman considered cutting edge. It showed me that we have a view of the world from our vantage points.

We are currently designing IPs and starting to support foundry customers on 10nm designs. We have many designs in process on 14nm and many designs in production on 22nm. Planar transistors have been history for a while; it is all tri-gate and multi-patterning lithography now.

Q. Will we hit a wall with advancing process nodes?

A. The inventor of Moore's law, Gordon Moore, said in his keynote speech at the International Solid-State Circuits Conference in 2003, that, “My law is about exponentials and no exponential will last forever.”

To me, it seems like we overindulge in speculating about the wall and the timing of when we will hit it. Our energy is better spent focusing on delaying that event, not predicting it. And perhaps there will not be a well-defined wall.

Q. Could you elaborate on how you see it?

A. The way I analogise it in my mind is that we are running in fog and it is getting denser. Leaders hear footsteps behind them and followers hear leaders' footsteps ahead of them. Leaders hope for the sounds of followers' footsteps to grow fainter and followers hope for the sounds of leaders' footsteps to grow stronger. Some are tired and would like the whole run to stop. Some are afraid they will run into a wall. And then there are some who focus on the run. I am part of the latter group of people.

Q. What kind of challenges do you see at the fab level, for each successive technology node improvement?

A. New transistor architectures based on new materials and lithography to print and resolve smaller and smaller dimensions are the major challenges.

Q. Does the equipment set change for every node?

A. No, Intel targets approximately 20 per cent change to the equipment set when defining the next node.

Q. Does change in product architecture affect the fab equipment?

A. Product architecture changes are usually done within the scope of a defined technology. Equipment changes are driven by new technology definition. ●

“Could cause missiles to misfire, radar systems to crash”

Counterfeit products emerge in the market almost right after originals are launched. The top five types of semiconductors reported as counterfeits represent US\$ 169 billion in potential annual risk for the global electronics supply chain, according to information and analytics provider IHS. How do we ensure that a counterfeit product does not turn a missile into a ticking time bomb? John Cronin, vice president of operations, North Shore Components Inc., the USA, speaks with Dilin Anand of EFY



JOHN CRONIN

VICE PRESIDENT OF OPERATIONS,
NORTH SHORE COMPONENTS INC.

Q. What level of damage can we expect from electronic systems running on counterfeit components?

A. Many components that are counterfeited are usually of a very high technical level. These may have a critical function in the product that these are contained in. The real concern started when the Department of Defence (DoD), the USA, realised that counterfeit components could cause severe problems. These could cause missiles to misfire, radar systems to crash or night vision goggles to cut off in the middle of military activity.

Q. What are these parts counterfeited with to have such an impact on systems?

A. In most cases, a part is selected whose physical characteristics might be identical or the electrical side may be similar. In some cases, a commercial version of the chip is taken and a military part number is put on it. Parts are disguised as if these were tested to extreme levels. These may pass testing, but when pushed to an extreme level, these components may fail, possibly taking down systems that these have been placed in.

Q. How do these counterfeit components make their way into military electronics?

A. Many products used today in the US military are legacy or older products, whose components are no longer made. Therefore the military depends on surplus and excess inventory, and components that tend to be expensive. This factor got the attention of counterfeiters and led to this being the class of products that were counterfeited first.

Q. How do manufacturers end up with counterfeits of their own components?

A. In the system of returns, an authorised distributor may send parts to a customer who may then return these, and the authorised distributor may not inspect the product properly. In some cases, they end up taking back counterfeit material instead of actual material, and therefore end up participating in distributing counterfeits. This gives a false sense of security to original

equipment manufacturers that they are buying through authorised distribution channels.

Q. Were these counterfeits first found only in the supply chain or in military systems too?

A. When this concern about vulnerability to counterfeits came up, the DoD required all of their contractors to review their products and come up with a list of affected equipment. And they soon started finding counterfeit components throughout both the systems and the supply chain. Concerns were so great that the DoD issued regulations requiring their contractors to ensure they had counterfeit mitigation processes in place.

Q. When looking at electronic components, where does the testing begin?

A. Ninety five per cent of the discovery is made during visual examinations. Simply by using a razor blade and scraping the surface of the part, you can see if the paint chips off. This should not happen, obviously.

In other cases, the part marking might come off. Another way is to use a cotton swab with certain chemicals on it and swipe it over the top and see if it erases the part number. These are the easy ones. Sometimes these parts are laser-marked, and therefore might not be easily noticeable as counterfeits.

It is also possible to test using X-rays. This may verify if the die is consistent throughout the part we are working with and if all connectivity is there. Another type is decapsulation tests, where we remove the covering of the part and visually see the die; we can document what is actually on the die itself. We also authenticate the markings on the die.

Q. What kind of visual markings do you usually pick up?

A. Sometimes, using a microscope we can see if they have sanded the part or pick out if they have over sprayed while doing the black topping, or if they have filled up voids in the part. At times if we look very closely at the markings, we can see a second marking underneath. ●

Wireless Hotel Ordering System



AJITH MEMANA AND FAISAL RASAK

Traditional ordering systems consist of waiters handing over the menu to customers and taking orders from them. The waiter's performance is defined by the speed at which the order gets processed, and it might get delayed at times.

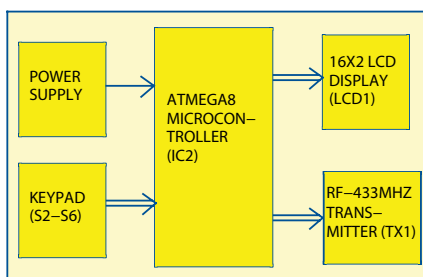


Fig. 1: Block diagram of the wireless hotel ordering system—transmitter side

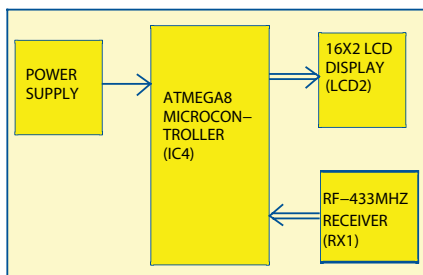


Fig. 2: Block diagram of the wireless hotel ordering system—receiver side

In the wireless ordering system, there is no waiter to take the order. Everything related to the waiter is done by the microcontroller (MCU) and a wireless transmitter. The customer can start ordering as soon as he or she is seated comfortably at the table. The delay caused by the waiter is eliminated in this system.

Circuit and working

The wireless hotel ordering system consists of a transmitter and a receiver section. The block diagram of the transmitter unit is shown in Fig. 1 and the receiver unit in Fig. 2.

The complete circuit diagram of the transmitter is shown in Fig. 3 and of the receiver is shown in Fig. 4.

Microcontroller. The heart of this circuit is an 8-bit AVR ATmega8 MCU

that controls, stores and coordinates the activities of the system. The software program stored in the MCU controls the functions of the system.

AVR combines the most code-efficient architecture for C language and assembly programming with the ability to tune system parameters throughout its life cycle. ATmega8 provides the following features: 8k bytes of in-system programmable flash with read-while-write capabilities, 1k byte of SRAM, 23 general-purpose I/O lines, 32 general-purpose working registers, three flexible timers/counters with compare modes, internal and external interrupts, a serial programmable universal synchronous asynchronous receiver transmitter (USART), an SPI serial port and five software-selectable power saving modes.

The flash program memory can be reprogrammed in-system through an SPI serial interface by a conventional non-volatile memory programmer or an on-chip boot program running on AVR core. With AVR's USART you just need to write the data to one of the registers of USART and you are free to do other things, while USART is transmitting the bytes.

Test Points

Test point	Details
TP0, TP4	0V (GND)
TP1, TP5	5V
TP2-TP3	Train of pulse when S4 button is pressed
TP6-TP7	Train of pulse when S4 button is pressed

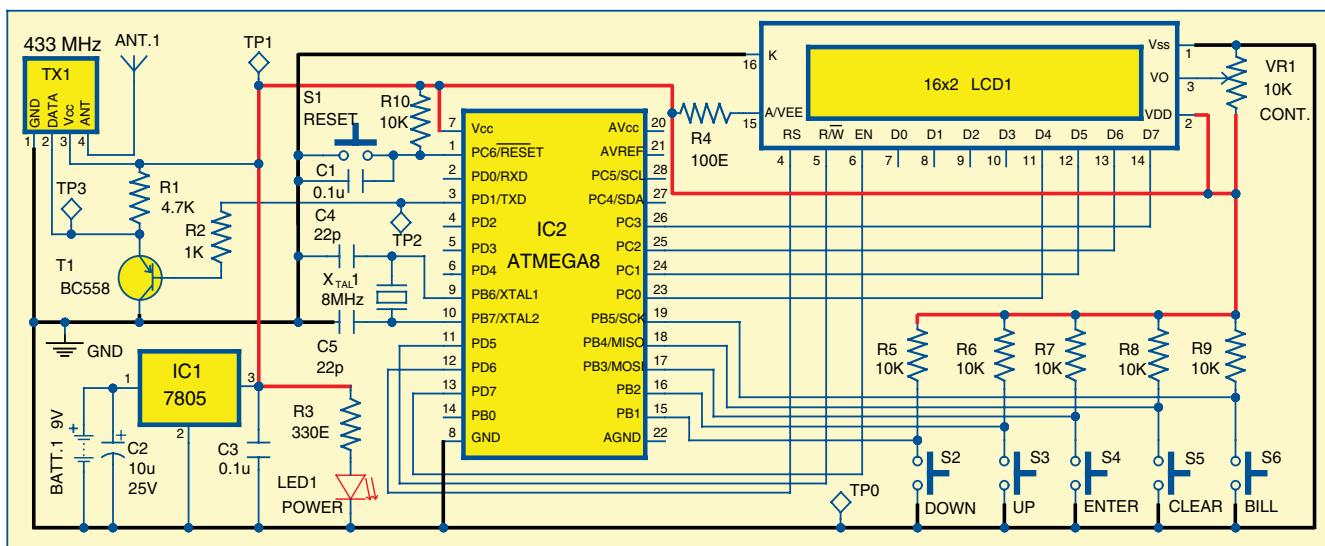


Fig. 3: Circuit diagram of the transmitter section

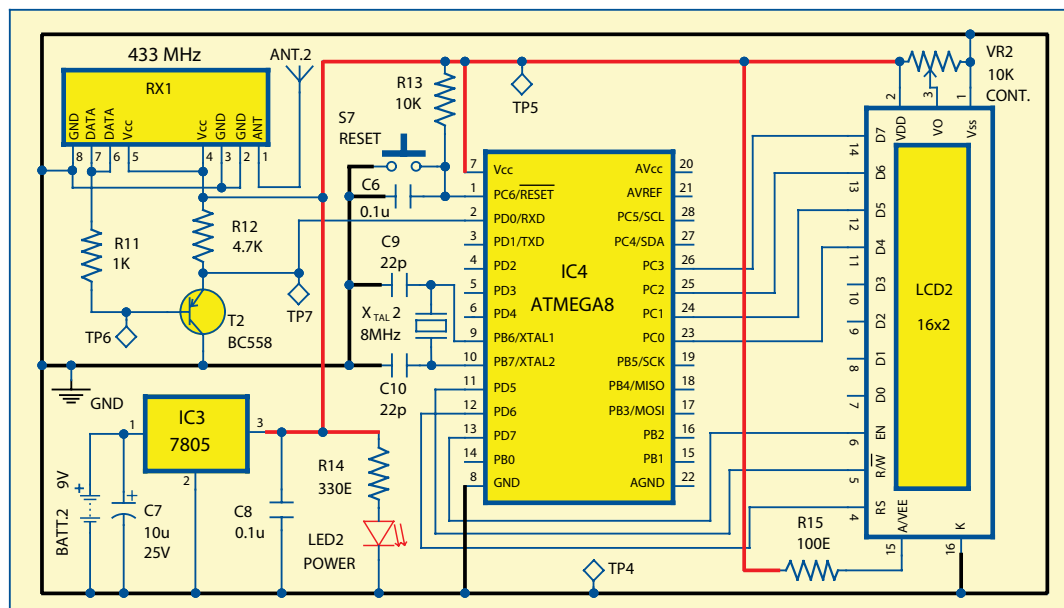


Fig. 4: Circuit diagram of the receiver section

PARTS LIST

Semiconductors:

IC1, IC3	- 7805, 5V regulator
IC2, IC4	- ATmega8, CMOS 8-bit microcontroller
T1, T2	- BC558 pnp transistor
LCD1, LCD2	- 16x2 LCD display
LED1, LED2	- 5mm LED

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

R1, R12	- 4.7-kilo-ohm
R2, R11	- 1-kilo-ohm
R3, R14	- 330-ohm
R4, R15	- 100-ohm
R5-R9, R10, R13	- 10-kilo-ohm
VR1, VR2	- 10-kilo-ohm preset

Capacitors:

C1, C3, C6, C8	- 0.1 μ F ceramic
C2, C7	- 10 μ F, 25V electrolytic
C4-C5, C9, C10	- 22pF ceramic

Miscellaneous:

TX1	- 433MHz transmitter module
RX1	- 433MHz receiver module
BATT.1, BATT.2	- 9V battery
S1-S7	- Tactile switch
X _{TAL} 1, X _{TAL} 2	- 8MHz crystal oscillator
ANT.1, ANT.2	- 17cm single-wire antenna

Keypad interface. The keypad consists of five tactile switches (S2 through S6), where each switch is assigned a particular function for up, down, enter, clear and bill functions in the transmitter unit. There is one reset switch each in transmitter unit and receiver unit, which is used if/when there is a problem in the LCD display.

LCD display module. The 16x2 LCD display is used for the user interface. The LCD is directly controlled

by the MCU. The LCD used is a 16x2 (16 characters by two lines) format type, driven by Hitachi HD44780 or an equivalent driver controller. The LCD module can display all alphabets and symbols as per ASCII format, and can store about eight custom characters.

The HD44780 has two 8-bit registers, an instruction register (IR) and a data register (DR). The IR stores instruction codes such as display clear and cursor shift, and address information for display data RAM (DD RAM) and character generator RAM (CG RAM). The IR can be written from the MCU but not read by it.

The DR temporarily stores data to be written into DD RAM or CG RAM and data to be read out from DD RAM or CG RAM by internal operation. Data written into the DR from the MCU is automatically written into DD RAM or CG RAM by internal operation.

The DR is also used for data storage when reading from DD RAM or CG RAM. When address information is written into the IR, data is read into the DR from DD RAM or CG RAM by internal operation. Data transfer to the MCU is then completed by the MCU reading the DR.

RF transmitter module. The RF433MHz transmitter module is for

ASK modulation using an RF transmitter tuned to 433MHz frequency. It features an in-built crystal oscillator and can be used to send bit-wise transmission. Orders given by the customer are encoded and sent wirelessly through this transmitter. The power supply can vary from 4V to 12V, depending on the range and power required. Data pin of the transmitter module is connected to TXD pin of IC2

through transistor T1 and resistor R2. An antenna of 15cm to 20 cm length is desirable for long-range communication.

RF receiver module. The RF433MHz receiver module can work in sync with RF433MHz transmitter. It receives signals sent by the transmitter. Receiver data pins are connected to RXD pin of IC4 through transistor T2. The receiver only needs 5V supply and an external antenna. This module is ideal for short-range remote-controlled applications, where cost is the primary concern.

Power supply. The system requires a regulated voltage of +5V for the MCU, LCD and RF modules. The battery voltage is converted to 5V, required for both transmitter and receiver units using IC 7805 regulator.

Capacitors are used in the input and output of IC 7805 to have more stability and to bypass transient signals. An LED in series with a current-limiting resistor acts as a power-on indicator.

Clock inputs. Crystal oscillators X_{TAL}1 and X_{TAL}2 are used as external clock sources in this project. Either a quartz crystal or a ceramic resonator may be used. For resonators, the maximum frequency is 8MHz if CKOPT fuse bit is unprogrammed, and 16MHz

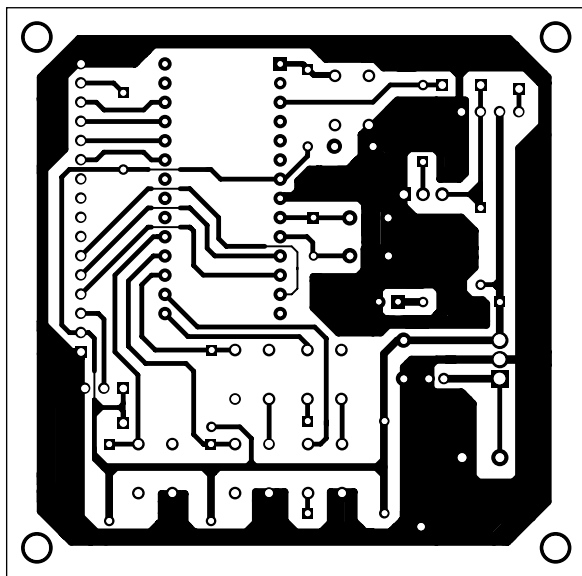


Fig. 5: Actual-size PCB of the transmitter unit

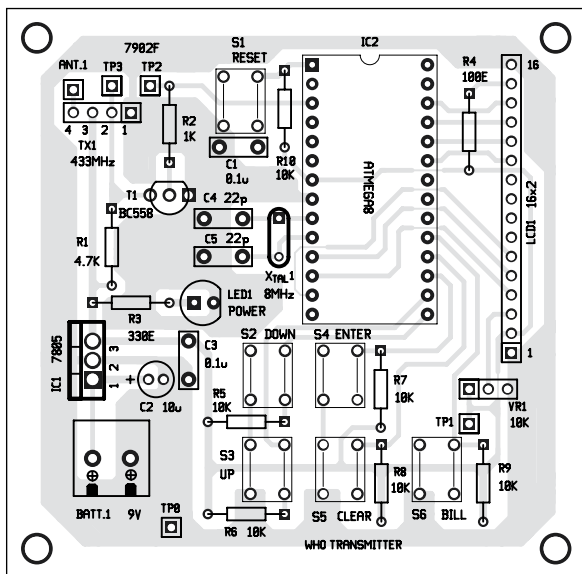


Fig. 6: Component layout of the PCB of the transmitter unit

if CKOPT fuse bit is programmed. Capacitor values for C4 and C5 in transmitter and C9 and C10 in receiver should always be equal for both crystals and resonators. The optimal value of capacitors depends on the crystal or resonator in use, amount of stray capacitance and electromagnetic noise of the environment.

Reset inputs. ATmega8 has four sources of reset, namely, power-on reset, external reset, watchdog reset and brown-out reset. Switch S1 is used as an external reset to reset MCU IC2, when a low voltage level

is present on the reset pin for longer than the minimum pulse length as defined in the data-sheet. Similarly, switch S7 is used as an external reset for IC4.

The transmitter unit will be energised as soon as the power supply is applied and the MCU will be reset due to the action of power-on reset circuit formed by capacitor C1 and resistor R10. The MCU will initially be in idle state and the LCD back light will be in low brightness in order to save power.

Welcome (in Malayalam) message language will be displayed in the idle state. In this state, the system checks the status of switches S2 through S6 connected to port B of ATmega8. When the user presses any switch, the system breaks from the idle state and jumps to the menu directly.

Now, the program is in continuous main loop. Since the LCD display contains only two lines, it can dis-

play only two messages at a time. The current selected item is highlighted by enclosing it within > and < symbols. The LCD display is updated only when a key is pressed, thereby avoiding updates in the loop.

By pressing Up or Down switch, the user can go to Previous or Next menu. The quantity of selected item can also be set using Up and Down. The price of the selected item is also displayed in the second line of the display. If the user wishes to cancel the order, he can press Clear, and

“Cancelled..” will be displayed on the LCD and the program will jump back to the main menu.

Pressing Enter will confirm the order, and “Sending..” will be displayed on the LCD and a code will be generated internally. This code will contain the item code and the number of items ordered. This code is transmitted serially using USART communication technique in AVR. After sending, “Sent” is displayed on the LCD and the program jumps to the main menu.

By pressing Up or Down, the user can review the order, including items ordered and the quantity. After ordering the required items, if the user wishes to view and verify the bill, he or she can press Bill and it will show the total amount in rupees.

Game. While the user waits for food, he or she can play Shooter game by pressing Game. The game features three custom characters and Enter shoots enemies.

Software program

Programming of the AVR is done using embedded C language. It is similar to C language but includes all functionalities of C as well as access to AVR pins, peripherals and controls. The Cross compiler used here is AVR-gcc, which is an open source compiler.

Hex codes generated are burnt into the MCUs for transmitter and receiver units. Working of the program is explained as comments in transmitter and receiver source codes.

The program jumps to the main function where the object code actually starts. Enter key causes the program to jump to the sub-loop of ordering. Pressing Enter will confirm the order and the entered quantity is stored in the item quantity variable in the program. The key de-bouncing problem is eliminated by the software by adding some delays for every key pressed.

Construction and testing

An actual-size, single-side PCB of the transmitter unit is shown in Fig. 5 and its component layout in Fig. 6. An actual-size, single-side PCB

of the receiver unit is shown in Fig. 7 and its component layout in Fig. 8.

You can also assemble the circuit on a general-purpose PCB. Before mounting the MCUs on the PCBs, burn the respective codes into the MCUs using a suitable programmer board. After mounting all components on the transmitter and receiver PCBs, switch on the power supplies on the respective units. LCD1 in the transmitter unit will display Welcome (Fig. 9) and LCD2 in the receiver unit will display Waiting 4 Orders (Fig. 10). Presets VR1 and VR2 are used for contrast control of the LCD displays. If there is any display problem, press reset switch momentarily and check the display again. For further troubleshooting the circuit, check voltages at various test points as given in the table.

Ordering procedure

1. Assuming the transmitter unit is installed near the table where the

customer is seated, when he or she presses a key, the menu appears. The user can browse items/menu using Up/Down keys. A typical menu is shown in Fig. 11.

2. If the user wants a particular item, he or she can select that item by pressing Enter, along with the quantity and again press Enter to confirm the order.

3. If the user wants to cancel the order, he or she can press Clear/Cancel.

4. After confirming the order, the item and quantity are sent to the receiver through RF wireless communication. The item and quantity are displayed on the LCD in the receiver unit. The receiver can be installed in the kitchen or in the room where the hotel manager sits.

5. The bill amount is calculated instantly after every order. The user can view the bill and verify at any time by pressing Bill.

6. While the user is waiting, he or she can play the game by pressing Game. The game is shown in Fig. 12.

Future scope

The cost-effectiveness and scope for extensive expansion proves to be effective not only for small and medium restaurants but also for premium and luxury hotels.

1. This technology can be coupled with RFID tags (like ID cards used in colleges or offices) for advance ordering of food items in college and office canteens.

2. Data analysis can be done by connecting to an external data processing machine, for example, a regular personal computer.

3. Extra voice channel transmission for spe-



Fig. 9: Welcome message in the transmitter unit



Fig. 10: Message in the receiver unit



Fig. 11: Typical menu on the LCD



Fig. 12: The game

EFY Note

The source codes of this project are included in this month's EFY DVD and are also available for free download at source.efymag.com

cial interaction can be done with the chef.

4. Automated serving system (pneumatic/robotic) coupled with this system can be implemented for a completely automated hotel. ●



Ajith Memana is B.Tech (electronics and communication) from FISAT, Mookkannoor/MG University. He is an Android developer at Qburst Technologies, Infopark, Kochi



Faisal Rasak is also B.Tech (electronics and communication) from FISAT, Mookkannoor/MG University. He is a game engineer at Tutitfrutti Games, Infopark, Kochi

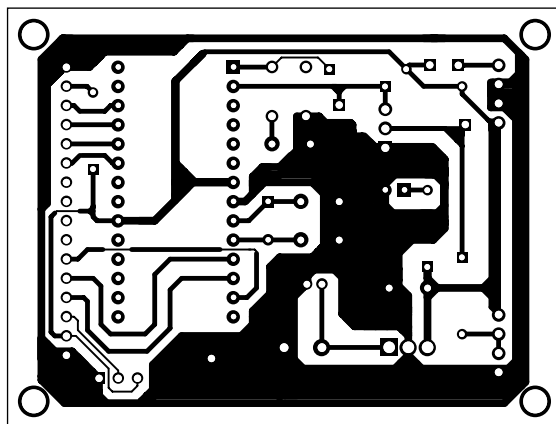


Fig. 7: Actual-size PCB of the receiver unit

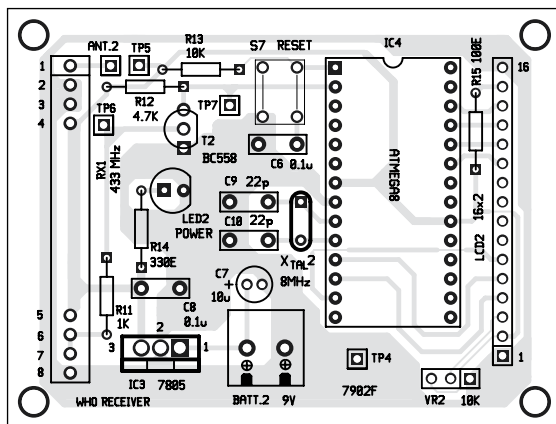


Fig. 8: Component layout of the PCB of the receiver unit

Museum Watchdog

T.K. HAREENDRAN

Theft at a museum means more than just the loss of an object, as it affects the historical, artistic and scientific value of the collection as a whole. A museum watchdog is a unique security alarm system, designed specifically to help prevent theft of valuable items on display.

This self-contained alarm widget provides a flexible, cost-effective solution for museums, art galleries, historic houses, heritage properties and corporate offices, among others. Fig. 1 shows an object placed on a plinth in a museum.



Fig. 1: An object in museum

This circuit is a simple magnetic-proximity detector pad, which senses the presence

or absence of a permanent magnetic field that triggers an audio-visual-alert generator when an object is removed from its current position.

The watchdog circuit is unobtrusive since there are no wires or chains hooked to the object being protected; only the object on display is visible.

Circuit and working

Fig. 2 shows circuit diagram of the museum watchdog. It employs a 14-stage binary/ripple counter IC CD4060 (IC1), reed switch S2 and a few other components.

The reed switch sensor is primarily intended to be used with a thin neodymium magnet (the strongest type of permanent magnet commercially available). The switch is fitted to the platform of the plinth, and the magnet is attached to the bottom of the object itself such that when the object is lifted,

the reed switch sensor contact opens. This enables IC1 and buzzer to start beeping. At the same time LED1 starts blinking, which serves as a visual indication.

Power supply for the circuit is provided by a standard 9V battery.

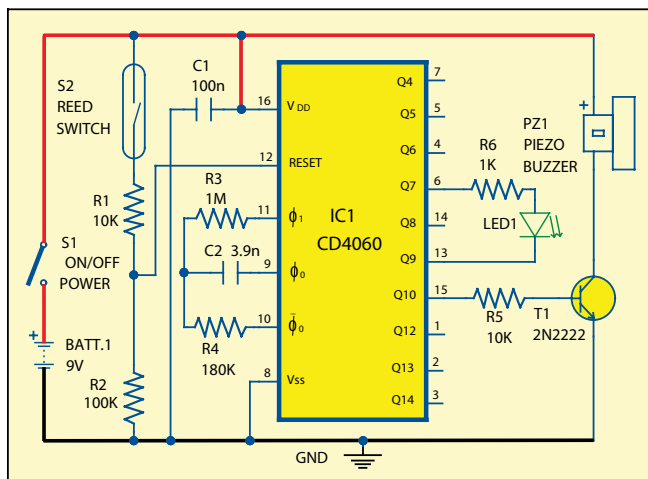


Fig. 2: Circuit of the museum watchdog

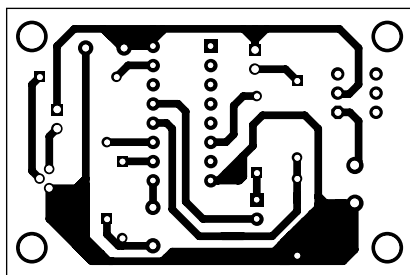


Fig. 3: Actual-size PCB of the museum watchdog

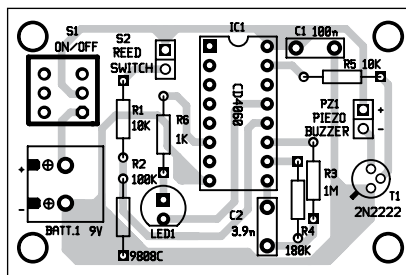


Fig. 4: Component layout of the PCB

PARTS LIST

Semiconductors:

- IC1 - CD4060 14-stage binary/ripple counter
- T1 - 2N2222 npn transistor
- LED1 - 5mm LED

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1, R5 - 10-kilo-ohm
- R2 - 100-kilo-ohm
- R3 - 1-mega-ohm
- R4 - 180-kilo-ohm
- R6 - 1-kilo-ohm

Capacitors:

- C1 - 100nF ceramic disk
- C2 - 3.9nF ceramic disk

Miscellaneous:

- BATT.1 - 9V battery
- S1 - On/off switch
- S2 - Reed switch
- PZ1 - Piezo buzzer
- Neodymium magnet
- 2-pin connector terminal

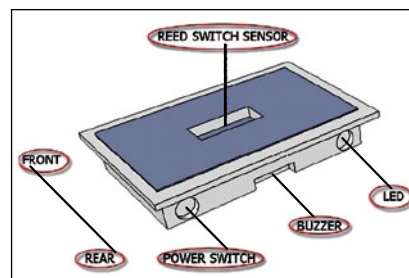


Fig. 5: Suggested enclosure

Construction and testing

An actual-size, single-side PCB for the museum watchdog is shown in Fig. 3 and its component layout in Fig. 4.

Enclose the PCB in a suitable small box and connect the reed switch externally using wires. Follow the appropriate labels for the box as shown in Fig. 5.

Place the magnet (not shown here) near the reed switch in such a way that the switch is closed/shorted, and when the magnet moves away, the switch is opened.

To make it user-friendly, it can be mounted on a plastic casing to fit comfortably in any display plinth. Some form of glue is required to hold the magnet in place. For a smaller magnet, double-sided adhesive tape can be used.

Never use a hot glue gun on a neodymium magnet as the high temperature may demagnetise the magnet. ●



T.K. Hareendran is an electronics hobbyist, freelance technical writer and circuit designer

Wireless Low-Cost Luggage Security Alarm



**T. AYYAPPA SWAMY, CH. SAIDEEP
AND R. SURESH**

If someone tries to walk away, say, two metres, with your luggage, this circuit would sound an alarm to indicate that the luggage is being stolen. The alarm mimics a police siren that alerts the user and also scares the thief. As the distance

is very short, the user can catch him and get back the luggage. This device also makes sure that the owner never forgets about the luggage.

Circuit and working

The circuit of the wireless low-cost luggage security alarm has transmitter and receiver sections. Fig. 1 shows the transmitter section while Fig. 2 shows the receiver section.

The transmitter section is built around 5V regulator 7805 (IC1), an encoder HT12E (IC2), a 433MHz transmitter module (TX1) and a few other components. It requires

+5V DC power supply, which is obtained from regulator IC1. Switch S1 is used as power on/off switch.

Transmission enable pin 14 of IC2 is grounded as it is an active low input. So, when the circuit is switched on, it starts encoding according to the data given to its input and

address lines. The oscillator is activated by connecting an external 1-mega-ohm resistor (R1) between pin 15 and pin 16 of IC2. DOUT pin of IC2 sends serial data according to the input combination (where A0-A8 equals 11011111 and AD8-AD11 equals 1111) to the RF transmitter module.

Similarly, as shown in Fig. 2, the receiver section is built around 5V regulator 7805 (IC3), decoder HT12D (IC4), a 433MHz receiver module (RX1), tone generator UM3561 (IC5), low-power audio amplifier LM386 (IC6) and a few other components. It also requires +5V DC power supply, which is obtained from regulator IC3. Switch S2 is used as power on/off switch.

The receiver section consists of an RF receiving antenna that receives serial data sent by transmitter TX1 as transmission

Test Points

Test point	Details
TP0, TP6	0V (GND)
TP1, TP4	5V
TP2	Pulses during transmission
TP3	5V when switch S1 is closed
TP5	5V when switch S2 is closed
TP7	High during transmission and low when there is no transmission
TP8	3.3V

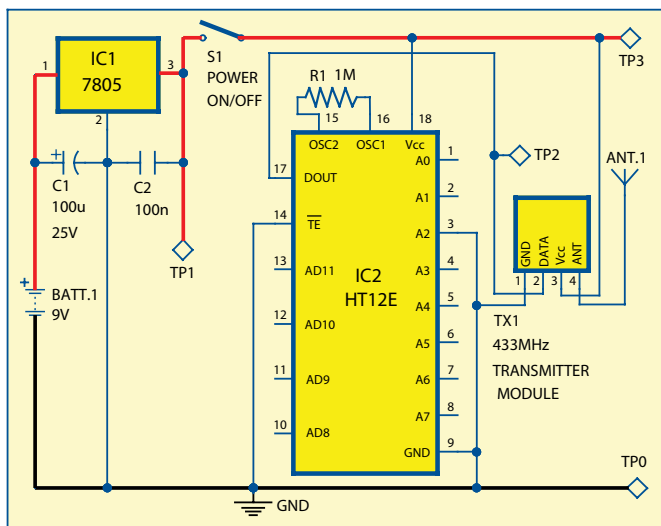


Fig. 1: Circuit of the transmitter section

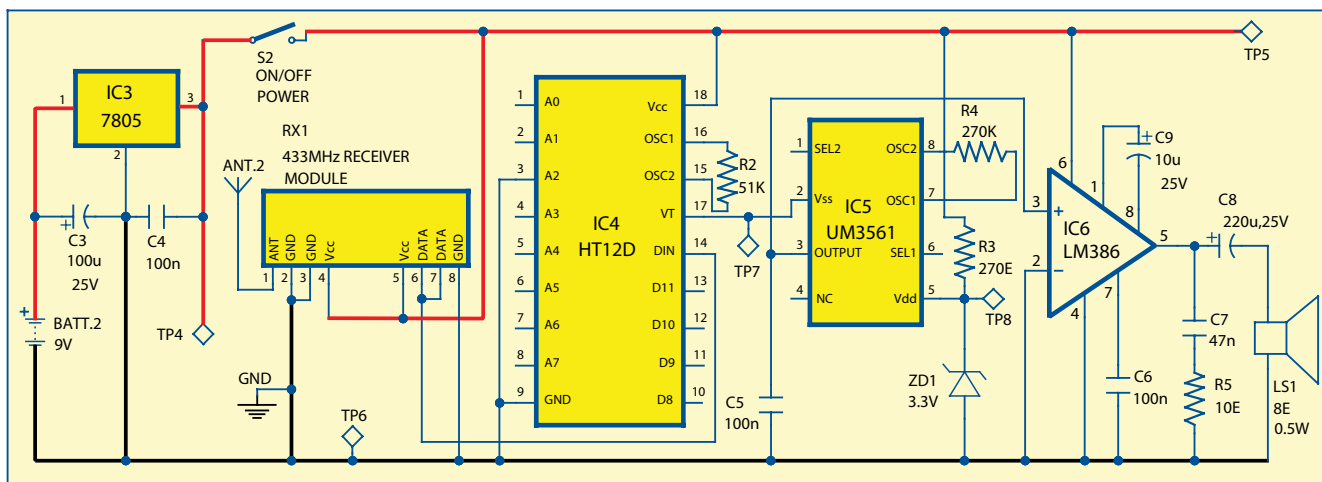


Fig. 2: Circuit of the receiver section

PARTS LIST

Semiconductors:

IC1, IC3	- 7805, 5V regulator
IC2	- HT12E encoder
IC4	- HT12D decoder
IC5	- UM3561 tone generator
IC6	- LM386 low-power audio amplifier
ZD1	- 3.3V zener diode

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

R1	- 1-mega-ohm
R2	- 51-kilo-ohm
R3	- 270-ohm
R4	- 270-kilo-ohm
R5	- 10-ohm

Capacitors:

C1, C3	- 100 μ F, 25V electrolytic
C2, C4-C6	- 100nF ceramic disk
C7	- 47nF ceramic disk
C8	- 220 μ F, 25V electrolytic
C9	- 10 μ F, 25V electrolytic

Miscellaneous:

TX1	- 433MHz transmitter module
RX1	- 433MHz receiver module
BATT.1, BATT.2	- 9V battery
S1, S2	- On/off switch
LS1	- 8-ohm, 0.5W speaker
ANT.1, ANT.2	- 17cm length single-wire antenna

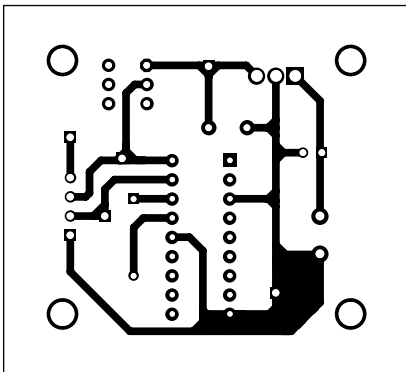


Fig. 3: Actual-size PCB of the transmitter circuit

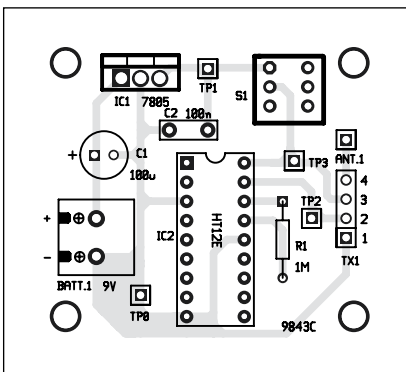


Fig. 4: Component layout of the transmitter

shown in Fig. 1. To generate clock pulses, oscillator pins 15 and 16 of IC4 are connected with an external resistance of 51k (R2).

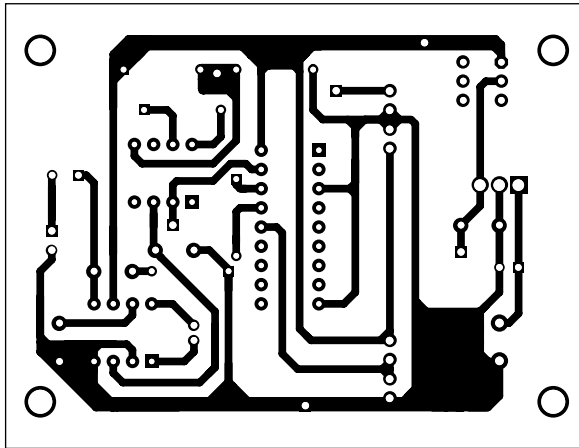


Fig. 5: Actual-size PCB of the receiver circuit

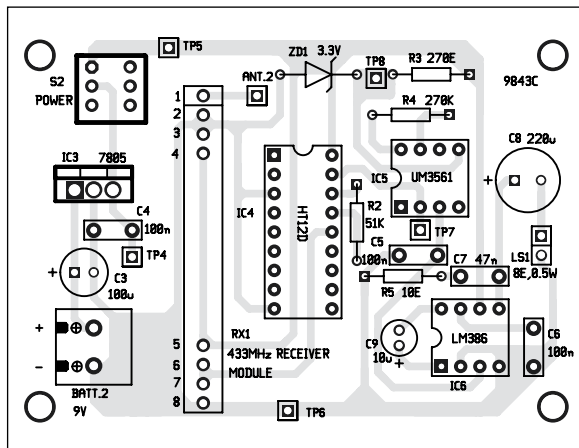


Fig. 6: Component layout of the receiver

The data output of RX1 is given to the data input DIN (pin 14) of HT12D decoder IC4. Incoming data is compared with already set address values. If valid data is received, valid transmission pin VT (pin 17) goes high and the data is accordingly transferred to the data pins. When valid data is not received, VT pin goes low, and vice-versa.

VT pin of IC4 is connected to Vss (pin 2) of UM3561 (IC5). UM3561 is a tone generator IC that gives three different tones, namely, police siren, ambulance and machine gun. These are obtained by different combinations of selection pins (SEL1 and SEL2) and oscillator pins (OSC1 and OSC2). Here, SEL1 (pin 6) and SEL2 (pin 1) of IC5 are left open to produce the police-siren tone.

Operational amplifier LM386 is used to amplify the output of IC5

to generate a louder sound. The gain of this op-amp can be from 20 to 200 by proper selection of external components between pin 1 and pin 8 of IC6. Here, the gain is set to 200. This is achieved by connecting a 10-micro farad capacitor (C9) between pin 1 and pin 8 of IC6. Output of IC5 is given to non-inverting input pin 3 of IC6 and the inverting terminal is grounded. The amplified output is taken from pin 5 through a 220-microfarad capacitor (C8) to an 8-ohm, 0.5W speaker (LS1).

During data transmission, LS1 does not produce sound because VT pin 17 of IC4 remains high to disable IC5. On the other hand, when transmission fails,

LS1 produces the sound as VT pin 17 of IC4 goes low to enable IC5.

Construction and testing

Separate PCBs are designed for transmitter and receiver units. An actual-size, single-side PCB for the transmitter circuit is shown in Fig. 3 and its component layout in Fig. 4. Similarly, an actual-size, single-side PCB for the receiver circuit is shown in Fig. 5 and its component layout in Fig. 6. Assemble both circuits separately and enclose these in two separate suitable small boxes. Ensure proper wiring to avoid any errors.

For troubleshooting, verify various voltages as given in the table. ●

All three authors are pursuing B.Tech (electronics and communication) from Maharaj Vijayaram Gajapati Raj College of Engineering, Vizianagaram, Andhra Pradesh

Simple Light and Sound Indicator for Mains Power Supply

PETRE TZV PETROV

While repairing or installing electrical machines in a building, the AC mains power supply is switched off from the mains electrical switchboard installed outside the building. There is a chance that someone who is not aware of the same may switch on the mains from outside. This poses a great danger for the technician working inside. Hence, an indicator like the one described here, which can be plugged into a nearby mains wall

socket, might prove very useful for the technician.

This circuit can also be useful for people who are living in a place where there is frequent mains power cut.

Circuit and working

The circuit diagram of the light and sound indicator for the mains power supply is shown Fig. 1. The circuit is built around capacitors C1 and C2, resistors R1 and R2, diode D1, zener diode ZD1, LED1 and a piezo buzzer (PZ1). Resistor R1 and capacitor C1 are used for reducing the voltage and limiting the current. Diode D1

is a rectifier. C2 is used as a filtering capacitor. Zener diode ZD1 limits the output voltage to around 12V. The value of zener diode should be equal to or lower than the maximum voltage of the buzzer and higher than the minimum voltage. Preferably, the buzzer should have a built-in oscillator working in the range of 6V-12V and requiring

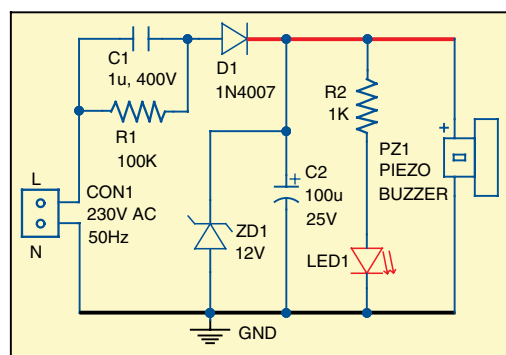


Fig. 1: Circuit diagram of the mains power indicator

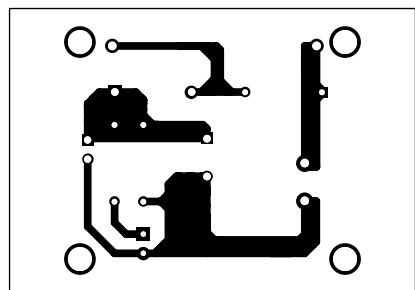


Fig. 2: Actual-size, single-side PCB of the indicator

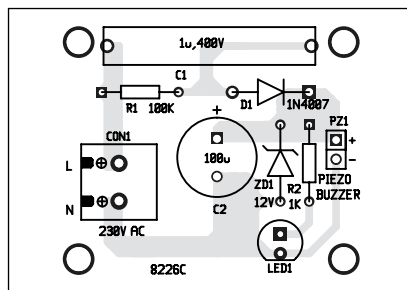


Fig. 3: Component layout of the indicator



PARTS LIST

Semiconductors:

- D1 - 1N4007 rectifier diode
- LED1 - 5mm LED
- ZD1 - 12V zener diode

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1 - 100-kilo-ohm
- R2 - 1-kilo-ohm

Capacitors:

- C1 - 1 μ F, 400V polyester
- C2 - 100 μ F, 25V electrolytic

Miscellaneous:

- CON1 - 2-pin connector terminal
- PZ1 - Piezo buzzer
- 230V AC mains power supply

a current below 10mA. The frequency of the alarm sound is usually in several kilohertz (kHz).

LED1 is on when the mains power supply is present, and at the same time the buzzer produces sound. Resistor R1, capacitor C1 and diode D1 are selected depending on the current requirement of the buzzer.

Construction and testing

An actual-size, single-side PCB of the simple light and sound indicator is shown in Fig. 2 and its component layout in Fig. 3. Enclose the PCB in a suitable small box in such a way that you can use it during repair work or installation. Ensure proper wiring to avoid any mistake. ●

Petre Tzv Petrov was a researcher and assistant professor in Technical University of Sofia, Bulgaria, and expert-lecturer in OFPPT, Casablanca, Kingdom of Morocco. He is currently working as an electronics engineer in the private sector in Bulgaria



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Air Motion Detector

PRADEEP G.

The project described here is of an air motion detector that can warn against strong winds. This is a simple circuit which can be very helpful for people who have no time to check the weather outside. It alerts them to collect their clothes drying in the sun, before strong winds take these away.

Circuit and working

Fig. 1 shows the circuit diagram of the air motion detector alarm. The circuit is built around a piezo sensor element connected across CON2, transistors BC549 (T1), BC547 (T2 through T5) and BC557 (T6), timer NE555 (IC1) in astable mode and other components.

The circuit uses the piezo element used in a buzzer as a sensor. If it senses strong winds, it generates electric pulses. Signals undergo multi-stage amplification by transistors T1, T2 and T3. Amplified signals are rectified and filtered. Obtained DC voltage is again amplified by transistors T4 and T5,

and given to the timer NE555 based oscillator through transistor T6, which is configured as a switch.

Normally, reset pin 4 of IC1 is held at ground level. When the sensor senses strong winds, transistor T6 is switched on, pin 4 of IC1 goes high and the alarm is activated, which produces sounds through the speaker.

Construction and testing

An actual-size, single-side PCB for the air motion detector is shown in Fig. 2 and its component layout in Fig. 3. Enclose the PCB in a suitable small box in such a way that strong winds can push the piezo element. Ensure proper wiring to avoid any mistake.

Test Points

Test point	Details
TP0	0V
TP1	9V provided when switch S1 is closed
TP2	Low (0V) when there is no wind and high (8.8V) when there is strong wind

PARTS LIST

Semiconductors:

- IC1 - NE555 timer
- T1 - BC549 npn transistor
- T2-T5 - BC547 npn transistor
- T6 - BC557 pnp transistor
- D1 - 1N4148 signal diode

Resistors (all 1/4-watt, $\pm 5\%$ carbon):

- R1 - 1-mega-ohm
- R2 - 4.7-kilo-ohm
- R3 - 220-kilo-ohm
- R4 - 10-kilo-ohm
- R5 - 3.3-kilo-ohm
- R7, R10, R14 - 1-kilo-ohm
- R8 - 10-ohm
- R9 - 100-kilo-ohm
- R11 - 2.7-kilo-ohm
- R12 - 47-ohm
- R13 - 470-ohm
- R15 - 56-kilo-ohm

Capacitors:

- C1 - 1nF ceramic disk
- C2, C4 - 100nF ceramic disk
- C3 - 100 μ F, 25V electrolytic
- C5 - 10 μ F, 25V electrolytic
- C6 - 47nF ceramic disk
- C7 - 10nF ceramic disk
- C8 - 47 μ F, 16V electrolytic

Miscellaneous:

- CON1 - 2-pin connector terminal
- CON2 - 2-pin connector
- S1 - On/off switch
- LS1 - 8-ohm, 0.5W speaker

To ensure proper working of the circuit, check the voltages at various test points given in the table. ●



Pradeep G. is B.Sc. (Physics) and a regular contributor to international magazines

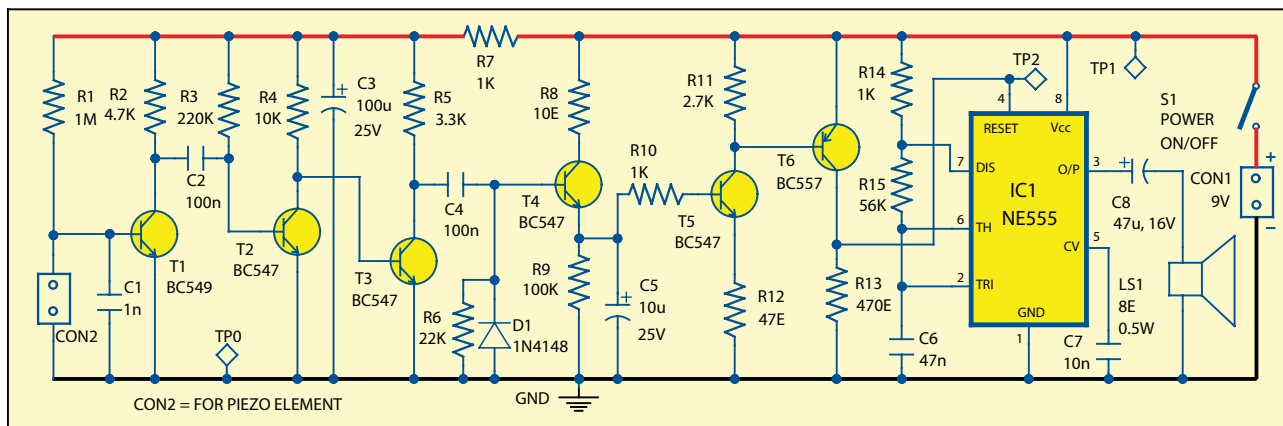


Fig. 1: Circuit diagram of the air motion detector

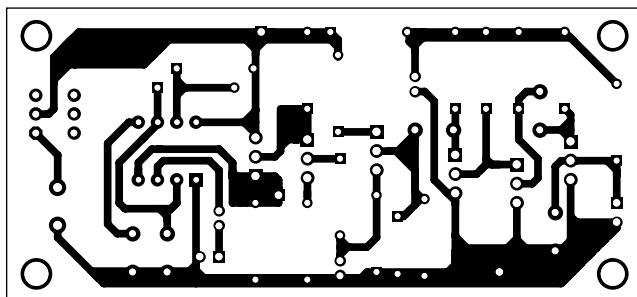


Fig. 2: Actual-size PCB layout of the air motion detector

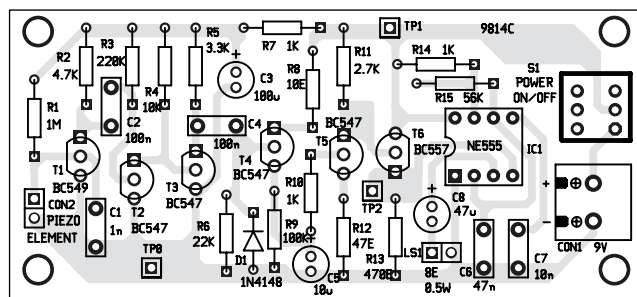


Fig. 3: Component layout of the PCB



Arduino Piggyback on Raspberry Pi

SOMNATH BERA

Arduino is a perfect mindless slave. Give it a job and it performs the task endlessly without defaulting even for a nano second. On the other hand, Raspberry Pi, or Raspi, is a computer that has a brain of its own. But, it may falter as it gets busy doing some other job at that moment. Imagine a situation where Arduino is doing the job and Raspberry Pi is supervising it!

Described here is a temperature indicator project using Arduino and Raspi boards. A temperature sensor such as LM35 gives analogue output. Arduino has analogue pins whereas Raspberry Pi does not. LM35 is interfaced directly to Arduino analogue pins and then connected to Raspi. It displays the temperature on the terminal. Let us see how.

Arduino set-up

Arduino development boards are available in many variants in the market. I have used Arduino Uno board for this project. The LM35 temperature sensor is easily available in India. It produces analogue voltage directly proportional to temperature with an output of 1mV per 0.1°C (10mV per degree). The sensor has a temperature range from -55°C to +150°C.

Connect LM35 sensor with Arduino as shown in Fig. 1 and then connect the USB cable to the computer. Open Arduino IDE, compile and upload the following `arduino_temp.pde` sketch (program) into the UNO board:

```
//arduino-temp.pde
byte n = 0;
const int tpin=0;
void setup(){
  Serial.begin (9600);
  pinMode(tpin, INPUT);
}
void loop() {
  int value=analogRead(tpin);
  float mv=(value / 1024.0 ) *5000;
```

```
float cel = mv / 10;
float far=(cel*9)/5 +32;
delay(1000);
if(Serial.available() ) {
  n = Serial.read();
  Serial.print ("character
  received:");
  Serial.println(char(n));
  Serial.println(n,DEC);
  if(char(n)=='c' ) {
    Serial.print(cel);
    Serial.print(":Deg Celsius");
    Serial.println("");
  }
  if (char(n)=='f') {
    Serial.print(far);
    Serial.print(" :Deg Farhenite");
    Serial.println("");
  }
}
```

```
else Serial.print("\nEnter c or f for
  temperature");
  delay(1000);
}
```

The sketch (program) converts `analogRead` values into millivolts and divides these by 10 to get degrees.

Run the sketch by opening Serial Monitor in Arduino IDE and write `c` to get temperature in Celsius and `f` to get temperature in Fahrenheit (Fig. 2).

So far so good!

Raspberry Pi set-up

You must have a Raspi board with basic set-up and an Internet connection. Install Python, Python-serial and any serial communication software, like

Putty or Minicom. I prefer Minicom communication software as it is very light and fast. To install these on Raspi computer, give the following command:

```
$sudo apt-get install
python python-serial
minicom
```

Now, in order to use Raspi's serial port, we need to disable `getty` (program that displays the login screen). To do this, locate the following line in file `/etc/inittab` by issuing the command given below:

```
$sudo nano /etc/inittab
```

A screen will pop up, where you need to remove a line that includes `getty` and `115200`. Just comment it out by adding `#` in front of the line as shown below:

```
#TO:23:respawn:/sbin/getty
-L ttyAMA0 115200 vt100
```

Save it and exit.

Now, when Raspi boots up, it sends data

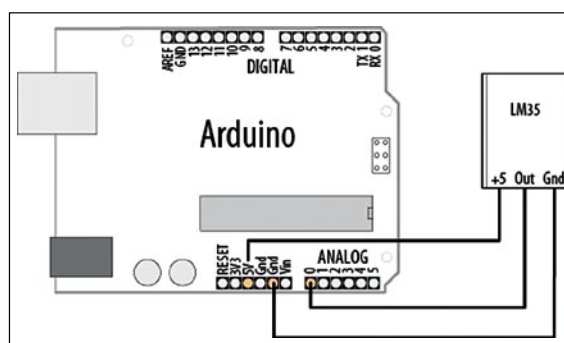


Fig. 1: Interfacing LM35 sensor to Arduino

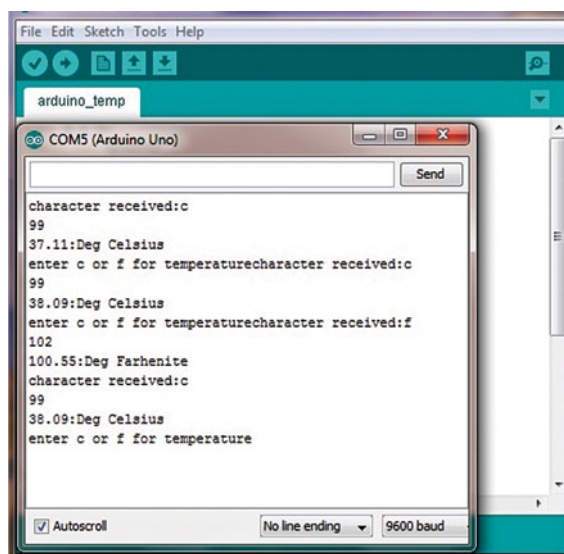


Fig. 2: Serial monitor

to the serial ports. We need to stop it from /boot/cmdline.txt file. This is a plain text file, parsed by Raspi as a text file. You need to remove a line from cmdline.txt file by issuing the following command. (You need to have a backup file of this, so save the original file as cmdline_backup.txt.)

```
$sudo nano /boot/cmdline.txt
```

Remove console=ttyAMA0, 115200 kgdboc=ttyAMA0, 115200 line.

Save and exit. Reboot your Raspi so that everything comes into effect.

EFY Note

The source codes of this project are included in this month's EFY DVD and are also available for free download at source.efymag.com

Arduino-Raspi connection

Arduino pin	Raspi pin
TX	10 (through resistor network as shown in Fig. 3)
RX	Pin 8 (direct)
Gnd	Pin 6 or pin 9 or pin 20 (direct)

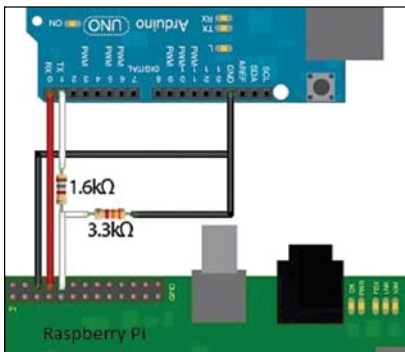


Fig. 3: Connection between Arduino and Raspi

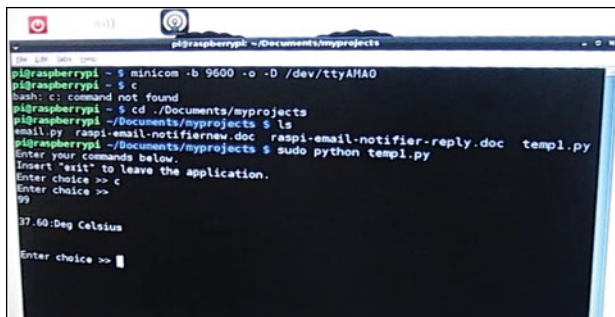


Fig. 4: Temperature reading on the terminal

Piggyback configuration

Arduino will sit on top of Raspi and then interact with the LM35 sensor. Arduino will give data to the serial port of Raspi.

GPIO 14 and GPIO 15 (physical pins 8 and 10) of Raspi are UART TX and RX pins. RX and TX pins of Arduino will just go into these GPIO 14 and 15 pins and the ground pin of Arduino will go to any one ground pin (physical pin 6, 9 or 20) of Raspi.

But, do not do that yet. Your Raspi board will be damaged beyond repair. The voltage level of Arduino output pin is approximately 5V, whereas that of Raspi is hardly 3V. We need to reduce Arduino I/O to the matching voltage level of Raspi using the circuit shown in Fig. 3.

Only three wires are to be connected, rest is the power supply that can be separate or common. Serial connection wires, TX and RX, will be interchanged with each other using a resistor network, as shown in the table, on Arduino TX pin to Raspi RX pin (pin 10).

Testing the project

Now, our main intention of making Arduino piggyback on Raspi is on the way. After connecting Arduino and Raspi, as shown in the table and Fig. 3, switch on the power supply of both boards.

Connect Raspi either through a headless mode or in direct mode (I always prefer the headless mode) and then run Minicom as follows:

```
$ ssh -Y pi@192.168.1.4
$ minicom -b 9600 -o -D /dev/ttyAMA0
```

Minicom has a help window that can be accessed by pressing Ctrl+a, z command to see more detail on Minicom.

Minicom will fetch the analogue data from serial port of Raspi and display it on the terminal

window. So, by using the command line and Minicom, we can bridge Arduino and Raspi boards for our application. To achieve this, we use Python program temp1.py to access the serial port of Raspi.

```
# temp1.py
import serial
import time
ser = serial.Serial('/dev/ttyAMA0', 9600,
timeout=10)
ser.open()
#ser.write("c")
print 'Enter your commands below.\r\n
      Insert "exit" to leave the
      application.'
input=1
while 1 :
    # get keyboard input
    input = raw_input("Enter choice >> ")
    # Python 3 users
    # input = input(">> ")
    if input == 'exit':
        ser.close()
        exit()
    else:
        ser.write(input)

    out = ''
    time.sleep(1)
    while ser.inWaiting() > 0:
        out += ser.read(1)
    if out != '':
        print "Enter choice >>" + out
```

Run the Python program by issuing following command:

```
$>sudo python temp1.py
```

As the serial console opens in Raspi, enter c to get temperature in Celsius or f to get temperature in Fahrenheit.

This is how you will be able to see temperature data coming from LM35 connected to Arduino, which is sitting piggyback on Raspi. The temperature output reading on the terminal taken during testing is shown in Fig. 4. ●



Somnath Bera is an avid user of open source software. Professionally, he is a thermal power expert working as additional general manager at NTPC Ltd

Pre-Primary Tutor Using Arduino



K. SITARAMA RAO

A simple tutor for kids is presented here. An Arduino board (or its equivalent Freeduino), three tactile switches and a 16x2 LCD module are the main components used here.

Arduino is selected because it is an open source prototyping electronics platform based on flexible, easy-to-use hardware and software. It is intended for designing creative applications by hobbyists, artists and engineers.

Circuit and working

The circuit diagram of the pre-primary tutor for kids is shown in Fig. 1. ATmega8 based board is used in this design.

Software is written in Arduino programming language, which is similar to C language. Software is written and compiled using open source Arduino integrated development environment (IDE). It can be downloaded from arduino.cc. Language structure, description and library functions are also given at arduino.cc. The compiled code is also uploaded on Arduino through Arduino IDE.

Switches S1, S2 and S3 are connected to digital pins 8, 9 and 10 of Arduino, respectively. These digital pins are programmed as input pins in set-up function of sketch. Programs written for Arduino are called sketches. The set-up function in sketch is used to set up pin modes, serial ports, etc. The actual functional code will be in the loop function of sketch.

When a switch is in open condition, the corresponding digital pin is connected to ground through pull-down resistors of value 10-kilo-ohm each. When a switch is pressed, the corresponding digital pin is con-

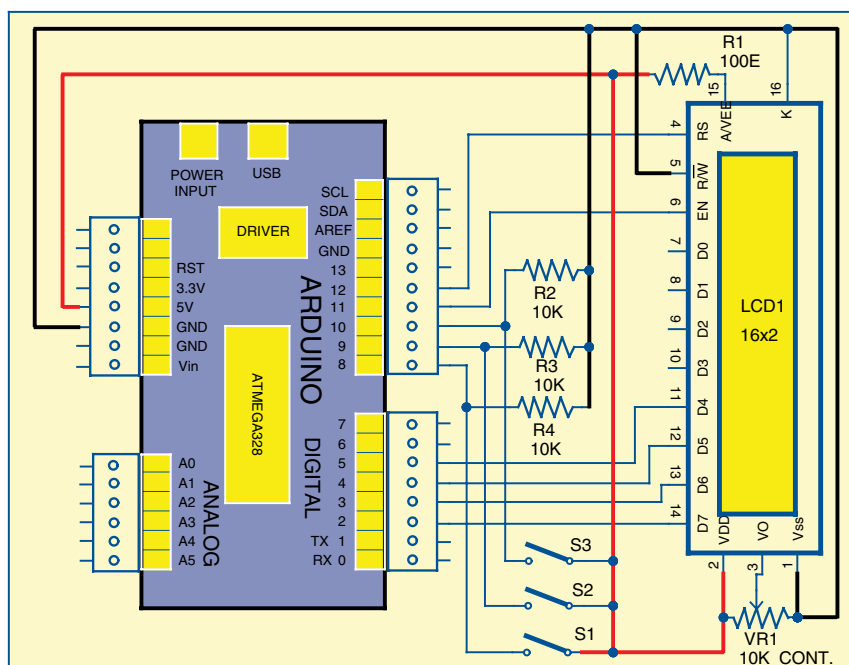


Fig. 1: Circuit diagram of the pre-primary tutor for kids

TABLE I
LCD Display in Mode 0

	Row 1	Row 2
Pressing S1 repeatedly	WELCOME	A a, B b, ..., Z z in a sequence
Pressing S2 repeatedly	WELCOME	A Apple, B Boy, ..., Z Zebra in a sequence

TABLE II
LCD Display in Mode 1

	Row 1	Row 2
Pressing S1 repeatedly	WELCOME	Increments multiplier value (a) from 1 to 20 in a sequence
Pressing S2 repeatedly	WELCOME	Increments multiplicand value (b) from 1 to 20 in a sequence Displays multiplication tables as $a \times b = c$

TABLE III
LCD Display in Mode 2

	Row 1	Row 2
Pressing S1 repeatedly	WELCOME	Sunday, Monday, ..., Saturday in a sequence
Pressing S2 repeatedly	January, February, ..., December in a sequence	31 days, 28/29 days, ..., 31 days; corresponding number of days for every month in a sequence

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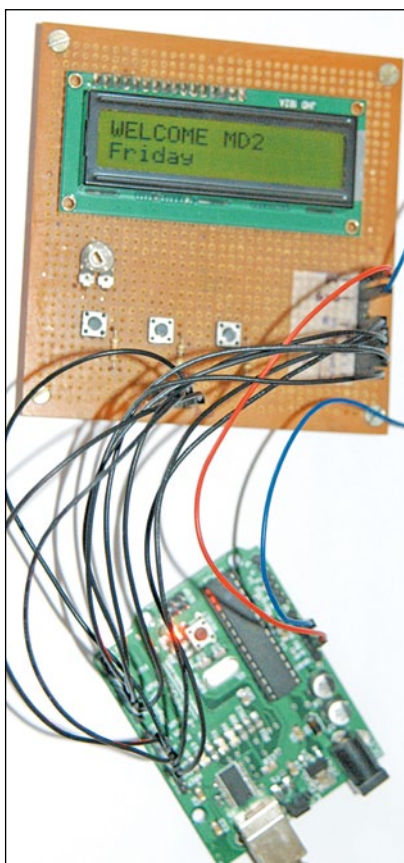


Fig. 2: Author's prototype

nected to 5V taken from Arduino. The switch-pressed states are read by digital read functions in the loop function of sketch.

The corresponding LCD display logic is also implemented in the loop function of sketch. Since switches S1 through S3 are tactile switches, contacts bounce during closure and release can cause false count. This problem is taken care of in the program by reading and comparing switch-closed conditions with a delay of 10ms.

Construction and testing

The circuit is wired on a general-purpose PCB. The prototype is shown in Fig. 2.

A USB A-B cable is used to upload the compiled sketch from the PC through Arduino IDE.

Photographs of some functions displayed on the LCD are shown in Fig. 3 and Fig. 4.

The operation is as follows:



Fig. 3: Multiplication result in mode 1



Fig. 4: Day of the week in mode 2

EFY Note

The source code (sketch) of this project is included in this month's EFY DVD and is also available for free download at source.efymag.com

Press switch S3 repeatedly to change mode from 0, 1 and 2. Then, press S2 or S1 to change contents of the LCD.

The various functions of switches and messages displayed on the LCD are listed in Table I through Table III. For example, in mode 0, if you press switch S1 momentarily, Welcome will be displayed in the first line (row 1) of the LCD. At the same time, A a will be displayed in the second line (row 2) of the LCD. If you press S1 again, Welcome in the first row and B b will be displayed in the second row of the LCD. If you press switch S2, Welcome in the first row and A Apple will be displayed in the second row of the LCD.

VR1 preset can be used to adjust the contrast of the LCD. ●

K. Sitarama Rao is M.Tech (control and instrumentation) from IIT Delhi. He is scientist G at Research Centre Imarat, DRDO, Hyderabad. He has been working in the field of missile quality and reliability for the last 15 years. He received Dr Lal C. Verman award on quality and reliability from IETE in 2010



Designing an Eight-Bit Arithmetic Logic Unit Using ModelSim



NIDHI KATHURIA

This project describes the designing of an 8-bit arithmetic logic unit (ALU) using Verilog programming language. It includes writing, compiling and simulating Verilog code in ModelSim on a Windows platform.

TABLE I
Pin Description of the ALU

Pin	Pin description
<A>	8-bit input signal A
	8-bit input signal B
<SEL>	6-bit selection signal
<S>	8-bit output signal
<O>	Output carry signal

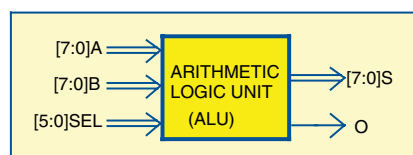


Fig. 1: Pin diagram of the ALU

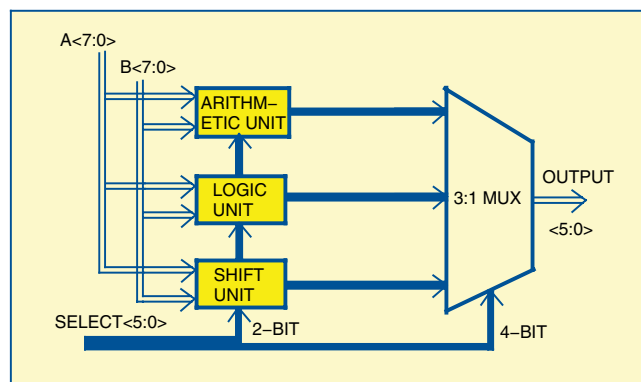


Fig. 2: ALU architecture

In digital electronics, an ALU is a digital circuit that performs arithmetic and bit-wise logical operations on integer binary numbers. It is a fundamental building block of the

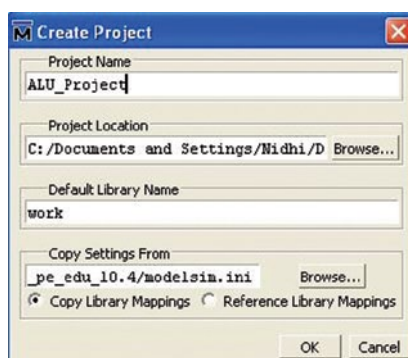


Fig. 3: Create Project window

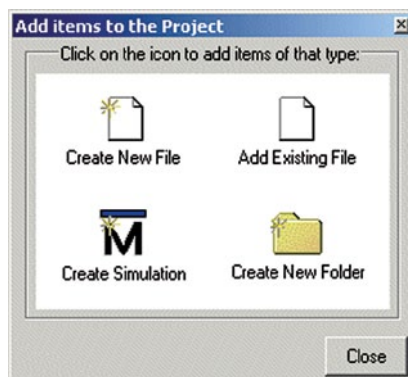


Fig. 4: Add items to the Project window

central processing unit (CPU) found in many computers and microcontrollers.

Inputs to an ALU are the data to be operated on (called operands) and a code indicating the operation to be performed, while the

TABLE II
ALU Functions Table

SEL	Function
<i>Arithmetic unit</i>	
0000	a+b
0001	a+b+1
0010	a+b-1
0011	a-b
0100	a-b-1
0101	a-b+1
0110	a==b
0111	a<=b
1000	a!=b
1001	a-1
1010	b-1
<i>Logical unit</i>	
0000	~a
0001	~b
0010	a & b
0011	~a & b
0100	a & (~b)
0101	~a & (~b)
0110	a b
0111	~a b
1000	a (~b)
1001	~a (~b)
1010	a ^ b
1011	~a ^ (~b)
1100	~(a & b)
1101	~(a b)
<i>Shift unit</i>	
0000	a<<1
0001	a>>1
0010	a>>1,out[0]=a[0]
0011	a<<1,out[7]=a[7]
0100	a>>1,out[0]=a[7]
0101	a<<1,out[7]=a[0]
0110	b<<1
0111	b>>1
1000	b>>1,out[0]=b[0]
1001	b<<1,out[7]=b[7]
1010	b>>1,out[0]=b[7]
1011	b<<1,out[7]=b[0]

ALU's output is the result of the performed operation. In many designs, the ALU also exchanges additional information with a status register, which relates to the result of current or previous operations. The pin diagram of the ALU is shown in Fig. 1 and its description in Table I. The ALU architecture is shown in Fig. 2 and its function tables are listed in Table II.

Software program

ModelSim is an easy-to-use yet versatile VHDL/SystemVerilog/Verilog/

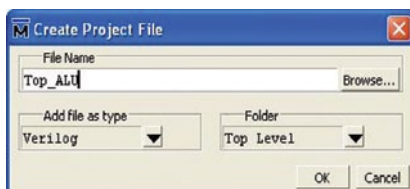


Fig. 5: Create Project File window

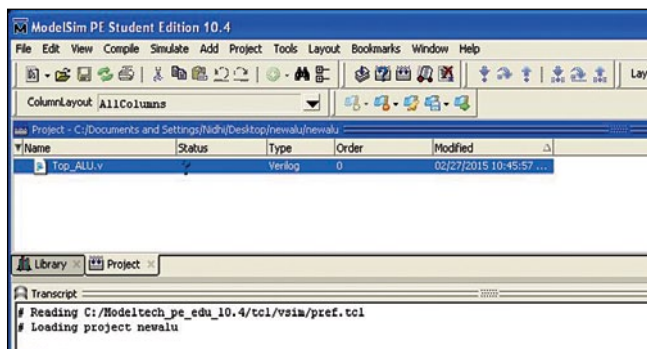


Fig. 6: Workspace window

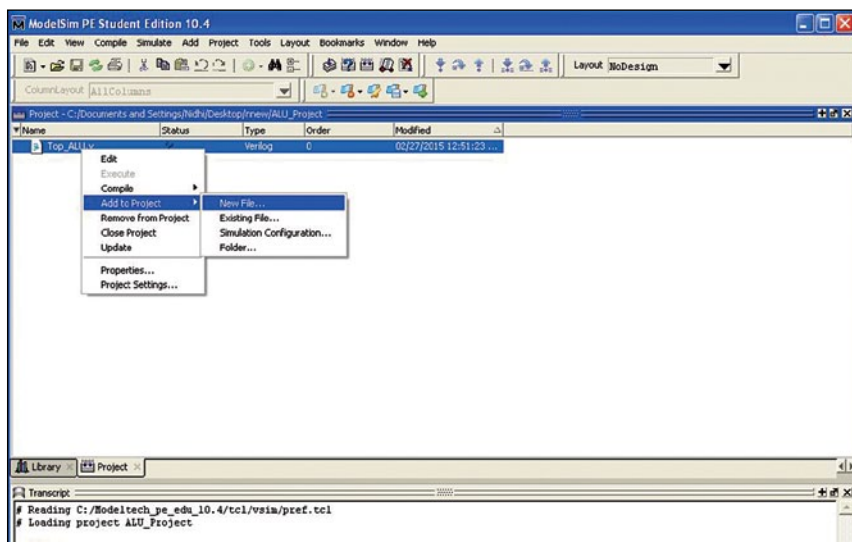


Fig. 7: Adding new files

SystemC simulator by Mentor Graphics. It supports behavioural, register-transfer-level and gate-level modelling.

First, install Mod-
elSim on a Windows
PC.

1. Start ModelSim from desktop; you will see ModelSim 10.4 dialogue window.
2. Create a project by clicking Jump-start on the Welcome screen.
3. A Create Project window pops up (Fig. 3). Select a suitable name for your project.

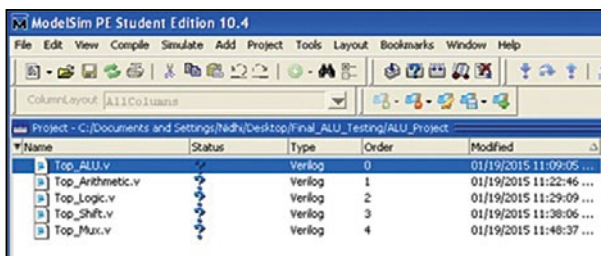


Fig. 8: Workspace section

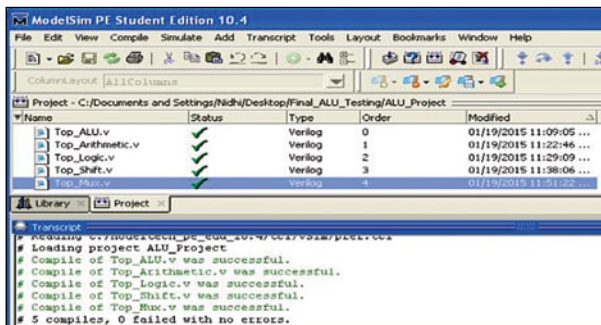


Fig. 9: Compilation window

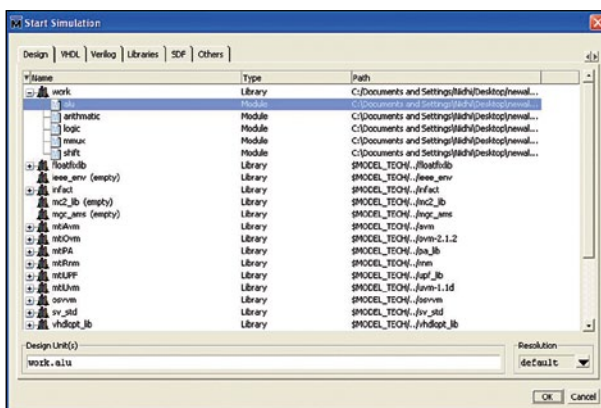


Fig. 10: Library tab

Set Project Location to C:/Documents and Settings/Nidhi/Desktop/Final_ALU_Testing (in our case) and leave the rest as default, followed by clicking OK.

3. An Add items to the Project window pops up (Fig. 4).
4. On this window, select Create New File option.
5. A Create Project File window pops up. Select an appropriate file name (say, Top_ALU) for the file you want to add; choose Verilog as Add file as type and Top Level as Folder (Fig. 5).
6. On the workspace section of the main window (Fig. 6), double-click on the file you have just created

(Top_ALU.v in our case).

7. Type in your Verilog code (Top_ALU.v) for an 8-bit ALU in the new window.

8. Save your code from File menu.

9. Now, add relevant files as per the architecture, which includes arithmetic, logic, shift and MUX units. Add new files to Top_ALU project by right-clicking Top_ALU.v file. Select Add to Project -> New File... options as shown in Fig. 7.

Give File Name Top_Arithmetic and follow the steps from five through nine as mentioned above.

Similarly, add Top_Logic, Top_Shift and Top_Mux files into the project and enter respective Verilog codes in these files.

The final workspace window is shown in Fig. 8.

Compiling/debugging project files

1. Select Compile-> Compile All options.

2. The compilation result is shown on the main window. A green tick is shown against each file name, which means there are no errors in the project (Fig. 9).

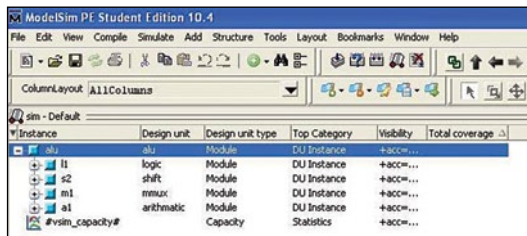


Fig. 11: Add wave to the project

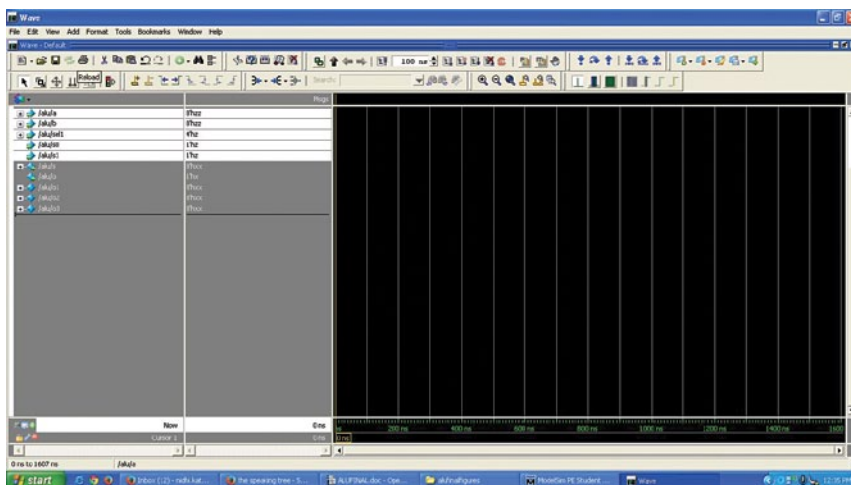


Fig. 12: Selecting the signals

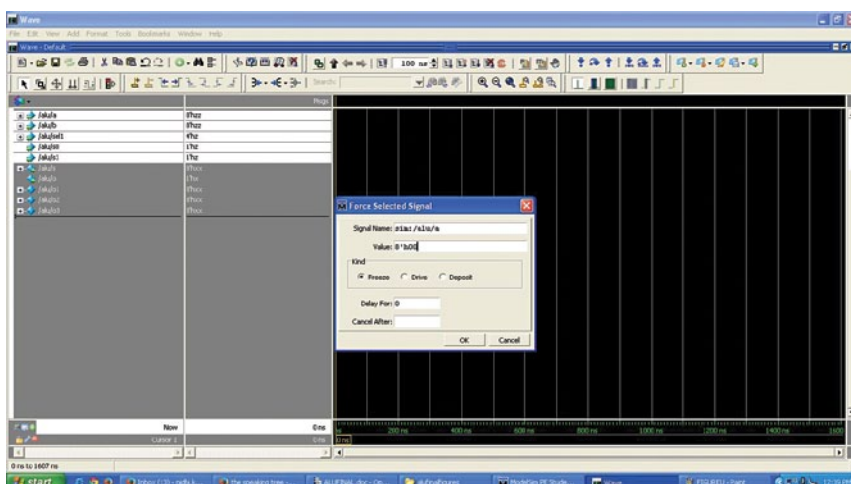


Fig. 13: Monitoring signals

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The screenshot shows the Waveform Editor in a logic analyzer software. The interface includes a menu bar (File, Edit, View, Add, Format, Tools, Bookmarks, Window, Help), a toolbar with various icons for waveform manipulation, and a list of signals on the left. The main area displays a waveform for the signal 'Data[0]'. A vertical cursor is positioned at 72 ns. The time scale is set to 100 ns. The waveform shows a sequence of data values over time, with a yellow vertical line indicating the current time position.

Simulating the ALU design

1. Click on Library menu from the main window and then click on the plus (+) sign next to the work library. You should see the name Top_ALU code that we have just

compiled (Fig. 10).

2. Double-click on alu to load the file. This should open a third tab similar to the main window.

3. Go to Add -> To Wave-> All items in region options (Fig. 11).

The source codes of this project are included in this month's EFY DVD and are also available for free download at source.efymag.com

4. Select the signals that you want to monitor for simulation purposes. Select these as shown in Fig. 12.

5. Provide values manually to monitor the simulation of the eight-bit ALU design.

Right-click on the selected signals and click on Force (Fig. 13).

After providing values to selected signals, we are now ready to simulate our design by clicking Run in the simulation window as shown in Fig. 14.

Now, click on Zoom Full from the wave window. Your simulation output waveform will be as shown in Fig. 15.

Thus, the result of the ALU design is verified from this output waveform.

Future applications

The ALU described here can be further refined to make more advanced-level projects with some more complex logics in order to handle complex calculations in the CPUs. ●



Nidhi Kathuria is senior application engineer at EFY Tech Center, New Delhi

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MP710 Music Player from Transcend

An old-fashioned portable media player

MP710 features a G-Sensor step counter, scheduled FM radio recording function, voice recorder, high-quality removable ear-hook earphones and a long battery life. It combines a number of features that give you an enjoyable workout time with music. Its fitness mode provides extra motivation by pre-setting and achieving your fitness goals. You can preset the amount of exercise before you start and the handy counter will help you track the progress of your activity.

MP710 also serves as an 8GB USB flash drive with data transfer and storage capabilities to save up to 2000 songs and countless ebooks and text files. Its 5.1cm (2-inch) full-colour TFT screen displays photos clearly and vividly from any angle, even in bright sunlight.

Price: ₹ 3999



Lenovo launches Yoga 3 Pro

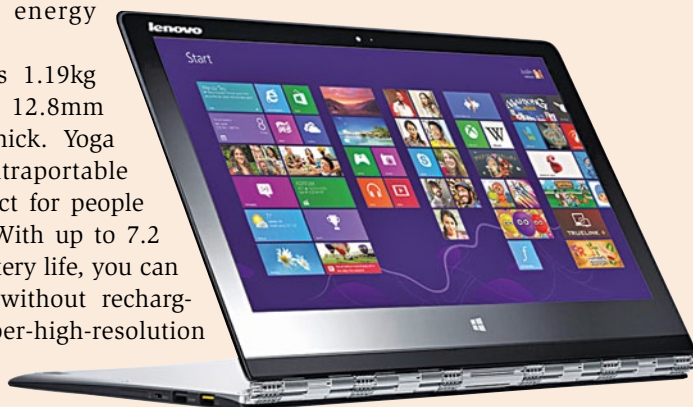
An intelligent laptop that adapts to you

Yoga 3 Pro can be used in four different ways: as a laptop, stand, tent and tablet. Its unique design and touchscreen display allows the screen to flip around 360°. It features Intel Core M processor, which is ideal for multi-mode devices that require high performance with great energy efficiency.

It weighs 1.19kg and is just 12.8mm (0.5-inch) thick. Yoga 3 Pro is ultraportable and is perfect for people on the go. With up to 7.2 hours of battery life, you can go all day without recharging. Its super-high-resolution

QHD+ (3200 x 1800) 10-point multi-touch display delivers amazing visuals, while in-plane switching (IPS) technology assures that images are crisp across a wide viewing angle.

Price: ₹ 114,990



Moto E 2nd Gen from Motorola

Made to last and priced for all

The new Moto E comes with Android 5.0 Lollipop operating system, Qualcomm Snapdragon 200 processor with 1.2GHz quad-core CPU, Adreno 302 with 400MHz GPU, 1GB RAM, 8GB internal storage (expandable up to 32GB via microSD card), 11.4cm (4.5-inch) qHD 540x960 245ppi IPS display, anti-smudge and water-resistant coating, 2390mAh battery, 5MP rear camera and VGA front camera.

On connectivity front, it supports Bluetooth version 4.0 LE and 802.11 b/g/n Wi-Fi. It also supports various sensors like accelerometer (x2), ambient light, proximity and sensor hub.



Price: ₹ 5999



**GizMo
ByTes**

Google rolls out Android 5.1 Lollipop

Google has rolled out Android 5.1 Lollipop, an update which improves stability and performance. It features several new features, like multiple SIM card support, high-definition voice calling on phones, device protection and more. Google has added a feature called Device Protection, where if the phone gets lost or stolen, it will remain locked until signed in with the user's original Google account. The phone would not work even if the device is reset to factory settings.

Vive, a virtual reality headset from HTC

The virtual reality headset, called Vive, allows the wearer to roam freely in a virtual world. The outside of the headset and hand controllers are packed with sensors that sync with two small transmitters that need to be placed in the room. These transmitters help Vive compute the user's position to a degree that allows him or her to reach out and grip objects in the virtual world with accuracy.

Apple launches ResearchKit

Apple has unveiled an initiative to help researchers tackle some of the world's most critical medical conditions by gathering data from willing iPhone users. This open source software framework makes it easy for researchers and developers to create apps that could revolutionise medical studies, potentially transforming medicine forever. The product will use data from medical tracking apps to aid research on asthma, breast cancer, cardiovascular disease, diabetes and Parkinson's disease.

Sennheiser MOMENTUM In-Ear Headphones launches in India

Uncompromisingly clear sound in a compact design

This newest member of the MOMENTUM family combines top-quality materials with superior craftsmanship. These are made of high-quality stainless steel, manufactured using precision milling technology, and the acoustic components contain no plastic. These earphones come in black and red colour variants.

With an ergonomic, adjustable angle of 15°, the buds adapt well to the ears. It features an extra-small sound tunnel and a choice of four ear sleeves to fit any size ear.

The range of accessories includes a sturdy hard-shell case, gold-plated jack, an intuitive remote for iPhone and Android,

elliptical cable that minimises tangling and sound loss, and integrated hands-free microphone.



Price: ₹ 6990

Swatch unveils Touch Zero One Smartwatch

For beach volleyball lovers

Beach volleyball is played all over the world, and now there is a new Swatch Touch that makes the game even more exciting. The new Swatch Touch Zero One combines design and new beach volleyball functions, like step counter, power hits and power claps, for players and fans.

The smartwatch has a curved touchscreen and built-in back-light to finger-tap and side-swipe access to six timing functions. Its battery is expected to last for months on end.



Price: ₹ 9800

Headphones for Enjoying Quality Music all the Time



Sanchari Banerjee is a correspondent at EFY

You may prefer high-energy tunes during a workout session, soothing music while in the privacy of your home, or you may just want to make your gaming experience more vibrant with peppy music. Whatever be the case, it is the headphones that reflect your personal style. There is a wide variety of headphones available in the market, so it is never an easy decision. Apart from the style factor, you must never compromise on the quality of sound. Here are some factors that you may keep in mind while shopping for headphones.

Know the different styles

Over-ear headphones. These headphones are also known as around-ear or full-size headphones. These have ear cushions that enclose the ears completely and prevent interruption from outside. These offer maximum bass and loudness levels, but sometimes cause overheating.

On-ear headphones. Design-wise, these headphones are similar to over-ear models. But these do not enclose the ears, rather







its cushions sit on the outer ears and are positioned perfectly by the elasticity of the headband. In comparison to over-ear models, these headphones have lesser bass. These are comfortable to use and also less prone to overheating.

In-ear headphones. These are also called in-ear monitors, or IEMs. These fit into each ear canal. Sports headphones mostly fit into this category. Most models are equipped with foam or rubber nubs, which ensure a custom fit. These headphones are excellent for passive noise reduction.

Earbuds. These headphones sit loosely on the ears. Some models come with clips for a more tailored and secure fit. Earbuds are lightweight and provide medium- to high-level isolation from external sounds. But the sound quality and bass response are not as good as full-size models'. If used for a longer duration, these earbuds can cause uneasiness too.

Wireless headphones. Music is transmitted to these headphones wirelessly through Bluetooth and, quite obviously,

SOME HEADPHONES AVAILABLE IN INDIA

	Philips SHQ1200 action fit sports in-ear headphones	Sennheiser Mx 170 in-ear headphones	Cowon EM1 earphones with remote and mic	AKG K403 on-ear headphones	Sony MDR-XB30EX extra-bass stereo in-ear headphones	Bose QuietComfort 15
						
Price	₹ 649	₹ 690	₹ 1149	₹ 1499	₹ 2190	₹ 21,263
Features worth looking at	<ul style="list-style-type: none"> Frequency response: 30Hz - 20,000Hz Impedance: 32ohm Wired connectivity Maximum power input: 10mW Headphone jack: 3.5mm Sweat and rain resistant; ideal for workouts Ultra-lightweight 	<ul style="list-style-type: none"> Frequency response: 22Hz - 20,000Hz Impedance: 32ohm Angled jack plug: 3.5mm 1.2m symmetrical cable Weight: 14gm Optimised for MP3 players, iPods, iPhones and other portable media players Two-year warranty Wired, in-ear headphones with earbud design 	<ul style="list-style-type: none"> Frequency response: 20Hz - 22,000Hz Impedance: 16ohm 10mm dynamic canal-type headphone driver units Wired connectivity 	<ul style="list-style-type: none"> Impedance: 32ohm Best for portable DVDs Compatible with iPhones 3D-axis folding mechanism 	<ul style="list-style-type: none"> Frequency response: 4Hz-24,000Hz Impedance: 16ohm (1kHz) Driver unit: 13.5mm Power handling capacity: 100mW 	<ul style="list-style-type: none"> Noise reduction technology Lightweight Comfortable for hours TriPort acoustic headphone structure Single, detachable audio cable

The prices mentioned here are from various e-commerce portals and are subject to change.

sound quality is compromised. But some latest wireless headphones ensure that audio quality is not degraded much. As you can avoid the mess created by wires, these Bluetooth headphones are becoming more popular during workout sessions and for portable use. However, as soon as the battery dies, the music stops and the sound quality becomes less dynamic as compared to other models.

Key specifications

If you are planning to purchase a pair of headphones, there are three things that seek your due attention—size, type and technology, as per individual requirements. Here are some most important features that must be considered before investing in a new pair:

Bass. Headphones' bass is a thing that remains less satisfactory most of the time. You start comparing it with speakers and are disappointed. There are some manufacturers who customise their signature sound and emphasise on lower frequencies.

Weight and comfort level. You can analyse the sound quality quite easily but it is more difficult to understand whether you will find your chosen headphone as comfortable when used for a longer period of time. Your earpads might create excessive pressure on your ears or these can get hot after long use. Some headphones feel heavy after long hours of use. Usually lighter headband-style headphones are more comfortable.

Durability factor. You are investing a good amount of money into your headphones and you would not like to throw your headphones away after some months' use. Good headphones can even last a decade. Assess the quality of your shortlisted headphones.

Frequency response. Frequency response means the range of frequencies a pair of headphones can reproduce. Each design has its own signature sound, and it is impacted by several other factors.

Sensitivity. A headphone's sensitivity measures the relative amount of volume it produces from a certain

amount of input power. Headphones having high sensitivity levels are recommended for portable devices.

Impedance. It is the measure of electrical resistance and is related to sensitivity.

Other key factors that require your due attention include noise reduction capabilities and the ability to keep volume at standard levels.

Be sure of the reason for your use

Home. If you are a serious music enthusiast, over-ear headphones are the best for you. If you find these heavy, there are many high-end on-ear and in-ear models for you to choose from.

Sports and workout sessions. Music plays a motivational role during these activities and lightweight in-ear or on-ear models are the best to keep you active and energetic. Comfort level should be kept in mind before choosing these headphones.

Workplace. You can keep yourself away from all the din and bustle in your office with over-ear headphones and concentrate on your work better. In-ear headphones with noise cancellation feature are also quite effective.

Gaming. Gamers get very serious at times. That is why excellent bass and high volume without any disturbance are highly recommended. Over-ear headphones could be the best choice.

Before you begin your search for the best-suited headphones for you, remember there is no one that can be called the best. Different headphones are meant for different purposes and it is only you who can decide which is the best for your needs. If you understand this fact you will save a lot of money. Do not look for a higher price tag as the most expensive headphones may not be suitable for you.

It would be preferable if you purchase your chosen pair of headphones from a retailer, be it local or its online counterpart, who offers a return policy. Online stores usually have a wide collection of all the latest headphones, but you need extra caution as you might get confused with such a flood of options. ●

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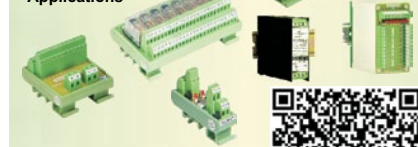
Operating Modes	ON Delay, Interval, Star Delta, Cyclic ON First OFF First, Forward-Pause-Reverse, True power OFF
Time Ranges	30 Sec, 60 Sec, 3/10/30/60 Sec/Min, 1/3/10/30 Sec/Min/Hr, 1/2/4/8 Sec/Min/Hr, 1/10 Sec/Min/Hr
Output Contact	# SPDT (1 C/O) # DPDT (2 C/O)
Contact Rating	5A @ 230VAC/ 24VDC
Supply Voltage	110VAC, 230VAC, 415VAC, 24VAC/DC, 20-240VAC, 12-240VDC



Size	72*72mm 96*96mm 144*144mm
Tone	2 Tone, 4 Tone, 110dB Output.
Flasher	With Flasher / Without Flasher
Accept Function	Push Button On Front and/or Terminals on Back
Volume Control	Yes, 10 to 100%
Supply Voltage	230VAC, 24VDC, 20-240VAC, 12-240VDC

Also Available

- SMPS (Din Rail Mount)
- Relay Interface Modules
- SSR Interface Modules
- FRC/ D-SUB connector
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Ahmedabad : Integrated - 09825709665 Ahmednagar : Tech Edge Controls - 09822012595
Ambernath : Chaudhary Enterprises - 09822066303
Ankleshwar / Bharuch : Maharshi - 09879061845
Aurangabad : Chintamani Electricals - 09850045468
Baroda : Omega Instrumentation - 09687513744
Bangalore : Certitude Tech - 08861876624
Chennai : Shree Krishna Enterprises - 09840332195
Deepak Agencies - 09840440065
Kochi : Alliance Automation - 09020480777
Coimbatore : Suriya - 09843356059
Delhi : Powertech - 09212260995
Durg : Aditya - 09827111400
Goa : Kedar - 09850041672
Jalna : Tech Edge - 09822012595
Karnal : Powertech - 09212260995
Kolhapur : Kedar - 09850041672
Madurai : Jagan Industrial Traders - 09843062834
Mumbai : Lohar Chawl : A. Harilal - 09321085554
Mahavir - 09821022778
Mulund : Yogesh - 9322251679
Andheri : Kalpesh - 932231500
Nasik : Nasa - 09422271456
Noida : Nelumbo - 09560311660
Pune : Pendse Electrical - 09325093840
Shrirampur : Tech Edge Controls - 09822012595
Silvassa : Vijan - 09824700675
Thane : VE Electricals - 09819646729
Vasai : Plaschem - 09371048482

Dealers enquiry solicited



R.S. Sharma, secretary, DeitY, government of India, at the inauguration of ELCINA CEO summit

Taiwan's ambassador to India, Chung Kuwang Tien, inaugurating ELCINA CEO summit at EFY Expo India, 2015



Electronics For You Expo India 2015

CELEBRATING THE SUCCESS OF THE INDIAN ESDM INDUSTRY

The Indian electronic system design and manufacturing (ESDM) industry is going all out to make the government's recently-launched Digital India and Make in India campaigns a success. The government is keen to make India self-reliant in electronics and turn the country into a global leader in electronics hardware manufacturing. The intention is to replicate India's success in software too.

Electronics ForYou Expo India 2015, an international exhibition organised by EFY Group and ELCINA Electronic Industries Association of India, promoted the Make in India concept by providing an ideal platform for innovators, designers, manufacturers and sellers in the industry to showcase the latest in electronics.

The buoyant local and international response to EFY Expo India (EEI) 2015, India's mega electronics show, truly proved that it is

an Indian exhibition for the global electronics industry. Members of the industry converged at this extravaganza, held at Pragati Maidan, New Delhi, from February 26-28, 2015.

Started in 2011, EFY Expo entered its fifth year in 2015, with an even better platform for business and networking. With more than 120 exhibitors showcasing their products under one roof, this electronics exposition turned out to be an appropriate platform for innovators, design engineers, manufacturers and traders of electronic systems and components. With the sole aim of accelerating the growth of the electronics industry in India, the expo focused not only on components and manufacturing equipment but the entire electronics ecosystem.

The expo was bustling with activity on all three days, and also led to some serious long-term business decisions being actualised by manufacturers and buyers.

Packed conference halls, buyer-seller meets and workshops running in parallel at the expo provided an informative insight into the Indian electronics industry. These proved beneficial for all stakeholders in the ESDM industry ecosystem, including senior-level decision makers in the industry. With an impressive footfall of more than 11,000 visitors, the expo saw many happy exhibitors and satisfied buyers. It offered business opportunities in various electronics sectors including components, test and measurement (T&M) equipment, training and educational solutions, PCB manufacturing, electronics manufacturing services (EMSes) and electronics design.

In continuation with this successful event, EFY Group plans to organise an even bigger and better *avatar* of the expo at Bengaluru next year. Rechristened as India Electronics Week, the event is scheduled for January 11-13, 2016.



CEO summit at EFY Expo India 2015

Key Attractions of The Show

VENDOR DEVELOPMENT SEMINAR

The vendor development seminar was organised to bring together buyers and suppliers. Speakers at the seminar were from companies that procure from the electronics components industry in large quantities, sharing a buyer's perspective. During the sessions, speakers shared a common view on the need of sourcing from local manufacturers to reduce the lead time to the market.

Focus of the lighting industry is on LED. It is important to achieve supply chain management excellence to ensure high-quality energy-efficient products. An efficient partnership with vendors can ensure the same and can create a win-win situation for both vendors and buyers. — **Paresh C. Shah**, supply chain and operations leader, GE Lighting

We have to understand that the sourcing process in the ESDM industry needs to be localised to drive Make in India campaign.

— **Sanjay Jain**, senior general manager - operations, Emerson Network Power India Ltd

We are procuring 100 per cent from India. The products we procure include PCBs, copper wires, plastics and sheet metal components, and we get good support from SMEs. — **Sarabjit Singh**, general manager - materials, NTL Electronics

The main focus should be on core technology as public sectors are looking at SMEs to support long-term business goals.

— **Yuvaraj A.R.**, additional general manager, CMS division, Bharat Electronics Ltd



Ramesh Chopra, executive chairman, EFY Group (first from left) with speakers at the vendor development seminar

BUYER-SELLER ZONE

EFY Group, in collaboration with ELCINA, had set up a special platform for large buyers across industries to meet new vendors and drive their vendor-development initiatives. The meet saw 17 large buyers, up from 13 last year, and more than 110 meetings were held.

17 buyers, 110 meetings

BUYERS AT EFY EXPO 2015

- Anchor Electricals Pvt Ltd
- Bharat Electronics Ltd (BEL)
- Emerson Network Power India Pvt Ltd
- Fiat India Automobiles Pvt Ltd
- Flextronics Technologies India Pvt Ltd
- GE Lighting
- Intex Industries
- Magneti Marelli India Pvt Ltd
- Maruti Suzuki Ltd
- Moser Baer Ltd
- NTL Electronics India Ltd
- Pricol Ltd
- Renault Nissan
- Stanley Black & Decker India Ltd
- Su-Kam Power Systems Ltd
- TJ Stratsource LLP
- VE Commercial Vehicles



TEST AND MEASUREMENT INDIA

India's leading T&M equipment providers exhibited at EEI, making it the only dedicated expo for this segment. The T&M showcase was a new initiative this year, as a part of T&M India, to demonstrate the latest T&M equipment to the industry. Some key participants included Rhode & Schwarz India, Anritsu India, Tektronix India and MetroQ, among others. The showcase gave insight into the latest equipment including digital storage oscilloscopes, analysers and handheld tools, specifically tailored for design engineers and academicians.



THE INNOVATION ZONE

With a goal of promoting the Made in India initiative, EFY Expo India 2015 showcased some cutting-edge innovations from Indian innovators. A special zone was created at the expo where innovators from all parts of the country showcased their innovations. Some interesting innovations included an autonomous underwater vehicle by Amogh, a system to simplify cars by CarIQ, wireless transmission of blood glucose readings from Diabeto and a device that can track keys or luggage from FIND, among others.



Key Attractions of The Show

ELCINA CEO SUMMIT

Through the expo, the two largest promoters of the electronics industry, ELCINA and EFY Group, are working together to take the electronics industry to the next level. The summit was aimed at celebrating the success of the ESDM industry and the roadmap ahead.

One of the important goals of Made in India campaign is that we should have zero imports in electronics by 2020 and become approximately a US\$-400-billion market by 2020. We import 70 per cent of electronics and to stop this import, the country has no option but to think of making in India. We are proud that in DeitY, we undergo continuous discussions with the industry before making any policy, which is why our policies do not face criticism. We do agree that every policy has a shelf life, which is why we keep interacting with the industry to update it from time to time. — **R.S. Sharma, secretary, Department of Electronics and Information Technology (DeitY), government of India**

When the government of India saw the dream of zero import by

2020, we thought why not make use of this opportunity. Madhya Pradesh is a state that has a surplus of power (uninterrupted power) throughout the year. Our labour laws have been revamped extensively in October 2014, and Madhya Pradesh is a state that has never witnessed industrial unrest. — **M. Selvendran, MD, Madhya Pradesh State Electronic Development Corp. Ltd**

During the summit some key announcements were made, including signing of an agreement between Infomax Communication, Taiwan, and Sahasra Electronics, India, to manufacture industrial mobile phones in India.

After the announcement of Make in India campaign by the government, Infomax invited Sahasra to look at their plants in Taiwan and the story concludes today as this agreement. We believe that these industrial mobiles will have a potential scope in India.

There are four pillars of the national electronics policy which include: EMC cluster scheme, MSIPS, PMA policy and EDF.



Sahasra Electronics and Taiwan's Infomax sign an agreement to manufacture industrial mobile phones in India, at ELCINA CEO summit

In early 2013, these parameters were defined and these motivated aspiring groups to get into electronics. As per the policy, there were seven verticals and every vertical had a threshold limit. If you invest beyond this, you get certain benefits. We took advantage of the scheme and submitted an application for the same to DeitY. We thought it will take at least two years to process but we were surprised they took it quickly, which is remarkable by any government department. — **Amrit Marwani, CMD, Sahasra Electronics**

Moreover, ELCINA announced that soon it will launch its first manufacturing cluster in Bhiwadi, and special efforts are being made by ELCINA to have greater participation and support from Taiwan for the electronics industry.

Government has taken many initiatives and I am sure all these initiative will lead India to create a competitive vibe across the globe and will also take the industry to a new level. — **Subhash Goyal, president, ELCINA**



SMT MANUFACTURING WORKSHOP

A half-day seminar was held by Kang Young Bong, managing director, YB Techsolution Pvt Ltd, and Kalpesh Sankhe of Kyoritsu Electric India Pvt Ltd, both experts with an experience of nearly two decades, from South Korea and India, respectively. The workshop highlighted the history of SMT, the current state of SMT in India, challenges, types of losses during use of SMT machines and how can this be overcome.

INTERNATIONAL EXHIBITORS

EFY Expo India 2015 saw more than 20 international exhibitors. Some of the international exhibitors participated as part of associations like China Electronic Appliance Corporation (CEAC), China, China Electronics International Exhibition and Advertising Co. Ltd (CEIEC), China, and Taiwan Electrical and Electronic Manufacturers Association (TEEMA), Taiwan.

While some exhibitors showcase regularly in India, there were many first-time exhibitors who plan to expand their reach in the Indian market. Most of these exhibitors were looking for Indian distributors in product categories including LED components, capacitors, RFIDs, SMT machines, touch displays and T&M products.



India is a very strong market for our products, which include MOFSETs, LED drivers, voltage protectors and others. We are currently looking for a distributor in India, and going further, we might look at a manufacturing unit as well. — **Sarah Wu, overseas sales, Din-Tek Semiconductor Co. Ltd**

We see a growing market for consumer durables in India, specifically mobile phones and even televisions and computer screens. We aim to engage with Indian manufacturers looking for touch displays for their products. — **Daniel Liu, general manager, Fortrend Taiwan Scientific Corp.**



Buyers' Feedback

We visit EFY Expo India for electronics procurement, and this time we see a larger number of Indian manufacturers showcasing their products. This shows that the Indian market is growing, with a stronger push from Make in India.

Tushar Patil, manager - sourcing, Anchor Electricals Pvt Ltd

A very good initiative. It is like Auto Expo, but is more informative and gives better chance for one-to-one interactions.

Mohit Gupta, DGM, VE Commercial Vehicles Ltd

The expo has been very good in bringing different manufacturers and suppliers under one roof.

Narendra Dogra, DGM - materials and purchase, Intex Industries

A very good forum that helped us interact with both small and big vendors. Overall, a good experience!

Yuvaraj A.R., additional general manager (CMS division), Bharat Electronics Ltd (BEL)

The show was well organised. It had an excellent choice of exhibitors and arrangements. The buyer-seller meet was very helpful. I met close to 17 sellers at the meet, which was very relevant with good time slots. Moreover, I found online appointments made in advance with sellers very useful.

Nandha Gopala Krishnan R., global supply management Asia - RM, Electronics & Fasteners Commodity-India, Stanley Black & Decker India Ltd

Exhibitors' Feedback

Since the government's Make in India initiative and important standards are going to be enforced very soon, we put up some dedicated products that can comply with the standards. We were able to meet some good prospects and get good enquiries in this expo.

Suvrat Verma, assistant manager, business development, Rohde & Schwarz India Pvt Ltd

The primary objective to participate in this show was branding and showcasing our test and measurement solutions. The overall theme of EFY Expo was very good—to bring all major T&M companies under one roof. We were able to meet some serious visitors.

Madhukar Tripathi, senior manager - marketing and sales, Anritsu India Pvt Ltd

I found this event interesting and informative with respect to Make in India campaign. I have attended the seminars and got good insight.

David Liu, global sales director, B. B. Battery

We have been associated with EFY Expo since its inception in 2011 and closely monitor its improvement on year-to-year basis. This year the best part was the proactive role of the organiser in arranging the buyer-seller meet. It helped exhibitors to get in touch with their right customers.

Sumit Sharma, marketing manager - India, Good Will Instruments Co. Ltd

The quality of EFY Expo is quite encouraging for us.

Sanjay Malla, CEO, Toradex Systems India Pvt Ltd

EFY Expo provided us with an opportunity to spread knowledge about SMT processes, manufacturing equipments and how to improve products and productivity, among industry players through the SMT workshop.

N.Y. Patil, general manager - marketing, Kyoritsu Electric India Pvt Ltd

We have participated in many international and national expos, but the quality of visitors at EFY Expo was superb. Most visitors spent 15 minutes on an average in our stall and showed genuine interest.

Haren Shah, chairman, Peach Technivations Pvt Ltd

We had a very good experience at EFY Expo. On the second day, we signed an MoU with our Taiwanese partner, Infomax, for the production of industrial mobiles in India.

Varun Manwani, director, Sahasra Electronics

It was a good show. We got good leads through this Expo. The overall quality of visitors was really good.

Mukesh Sharma, regional sales manager, Flir Systems

This year the Expo was a big success since there were three shows happening in parallel, so we had common visitors that led to increased footfall and focus. Many of our customers including prominent players in EMS and LED manufacturing used EFY as a platform to meet and discuss new requirements along with their product samples.

Padmanabha Shakthivelu, sales manager - India, Electrolube India

Experts' Feedback

“EFY Expo serves as a platform for enabling the growth of electronics manufacturing, design and R&D in India. It aims to provide an efficient platform for all stakeholders (small, medium and large, domestic or global) to understand the requirements of the Indian market and find avenues to serve this requirement locally and consequently encourage electronics manufacturing in India. What was interesting were the innovative products displayed, which can be exploited in the mainstream electronics industry going further. This was an excellent initiative to encourage design engineers and technology entrepreneurs. Moreover, the buyer-seller meet led to the creation of enhanced opportunities for the industry.

—**Subhash Goyal, president, ELCINA, managing director, Digital Circuits**

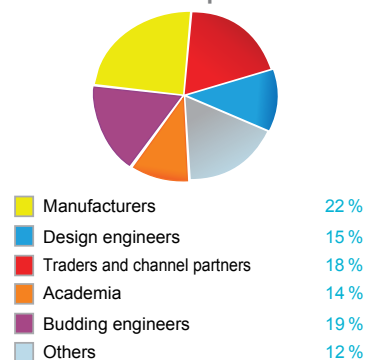


“EFY has done an excellent job in bringing the industry together. I also thank the government of Madhya Pradesh for being state partners and acknowledge the support of sponsors and delegates.

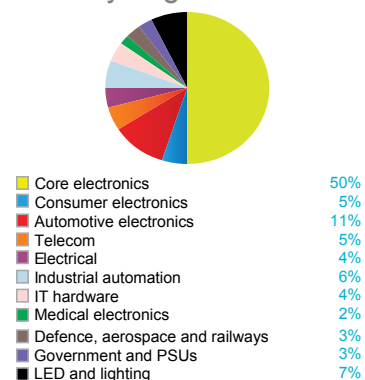
—**Vikram Desai, managing director, Desai Electronics Pvt Ltd**



Visitors profile



Industry segment: Visitors



Highlights of union budget 2015-16

The NDA government has announced its first full-fledged union budget. Finance minister Arun Jaitley, recognising the damage that inverted duties have caused to manufacturing in the country, has reduced customs duty on a number of inputs. He has abolished basic customs duty on imported raw material.

Jaitley has also looked at the excise duty structure applicable to certain items and carried out rationalisation to provide boost to devices like LED drivers, mobile handsets, tablets, computers, IC wafers and some specified raw materials, among others.



Finance minister outside Parliament House with budget papers in briefcase

This is believed to be a good beginning to realise the full potential of electronics hardware in restricting huge foreign exchange outflows and creation of substantial number of jobs. However, Jaitley has not been able to meet the expectations with respect to relief to tax payers, both corporate and individuals. The budget includes a proposal to reduce the corporate tax from 30 per cent to 25 per cent over the next four years beginning from the next financial year, but this will be accompanied by withdrawal of exemptions.

Jaitley has declared that the government is committed to a stable taxation policy and a non-adversarial

Vodafone India CTSO Burgess Coope quits

Telecom major Vodafone India's chief technology security officer, Burgess Cooper, has left the organisation after a nine-year stint to join global consultancy firm Ernst & Young. He was responsible for ensuring Vodafone's information security and privacy system. He also ensured compliance to ISO certifications in the organisation.

Infosys splits HR head role

India's second largest software services firm, Infosys, has undertaken an organisation reshuffle that will

In Focus

result in current global HR head, Srikantan Moorthy, moving to a new delivery function role. Binod Hampapur Rangadore, Executive vice president, will lead overall talent fulfillment function, which includes mass recruitment, training and personnel allocation.

Rishad Premji to head Wipro's CTO office

Rishad Premji, eldest son of Wipro chairman Azim Premji, who currently runs strategy, will now have the CTO office reporting to him. The office has around 200 people working on newer technology areas like cognitive computing.

system design and manufacturing (ESDM) industry, has announced the submission of detailed project report (DPR) for the proposed electronics manufacturing cluster (EMC) in Pune, Maharashtra, in association with Maharashtra Chamber of Commerce Industries and Agriculture (MCCIA).

As knowledge partners to MIDC and MCCIA, IESA has extended support to prepare and submit the preliminary application with the project report for a proposed common facilities centre (CFC) in Pune, under the guidelines of the EMC scheme of Department of Electronics and Information Technology (DeitY), government of India.

Government allocates funds to MSME sector

The government of India has allocated more than ₹ 33 billion, the highest allocation in the last three financial years, to develop the micro, small and medium enterprises (MSME) sector and is implementing a special programme to develop infrastructure to improve productivity and competitiveness of MSMEs in the country.

MSMEs account for more than 37 per cent of the GDP and more than

tax administration, which will, hopefully, encourage fresh investments. The 'Make in India' campaign will lead not only to the revival of growth and investment but also to the promotion of domestic manufacturing and enormous job creation. As a step to encourage the campaign, Jaitley has reduced the rate of income tax on royalty and fee for technical services from 25 per cent to 10 per cent, which should facilitate technology inflow.

IESA collaborates with MIDC and MCCI

India Electronics and Semiconductor Association (IESA), the premier trade body representing the Indian electronic

Calendar of Forthcoming Electronics Fairs/Exhibitions/Seminars/Events

Name, Date and Venue	Topics to be covered	Contact address for details
Hong Kong Electronics Fair (Spring Edition) April 13-16, 2015 Hong Kong Convention and Exhibition Centre, Hong Kong	Showcasing the latest electronics products, technologies and ICT solutions	Email: exhibitions@hktdc.org Website: www.hktdc.com
TECHTRADE 2015 April 16-20, 2015 Sabarmati Riverfront Ahmedabad, Gujarat	To promote the Make In India campaign and manufacturers of India and offer a platform to foreign participants to exhibit their products/services and explore possibilities of export/import and business tie-ups	ASSOCHAM India Phone: +91 80009 21521 Email: Info@techtrade.co.in Website: http://www.techtrade.co.in
Keysight Aerospace & Defense Symposium 2015 April 17, 2015 Bengaluru	For scientists, engineers, engineering managers, directors and CEOs, with technical focus on radars, electronic warfare, military communication and satellites	Keysight Technologies India Phone: +91 9900955220 Website: http://www.keysight.com
CONNECT Show April 21-22, 2015 Melbourne Convention and Exhibition Centre, Melbourne, Australia	For business people to understand how convergence of technology mega-trends will impact the way we live and do business	CONNECT Show Phone: +61 (2) 8908 8555 Email: admin@acevents.com.au Website: www.con-nect.com.au
NEPCON China 2015 April 21-23, 2015 Shanghai Expo Center, China	Features latest technologies and products in SMT, surface welding, electronic measurement, automatic electronic production, static electricity prevention and new materials	NEPCON China 2015 Website: http://www.nepconchina.com/
LED Expo 2015 May 7-9, 2015 Bombay Exhibition Centre, Goregaon, Mumbai	LED Expo has evolved as the biggest show exclusively for manufacturers, component and equipment suppliers, lighting specifiers and design engineers that are shaping the present and future of LED technology today	Messe Frankfurt Trade Fairs India Pvt Ltd Phone: +91 22 6144 5900 Website: http://www.theledexpo.com/
International CES Asia, 2015 May 25-26, 2015 Shanghai New International Expo Center (SNIEC) China	Tech powerhouses to innovative startups, 3D printing, robotics, sensors, the Internet of Things and wearables	Shanghai New International Expo Center (SNIEC), Shanghai, China Phone: 703.907.7603 Email: afried@ce.org
CommunicAsia 2015 June 2-5, 2015 Marina Bay Sands, Singapore	Part of Asia's largest infocomm and media business platform	Singapore Exhibition Services Phone: +65 6233 6638 Website: www.communicasia.com
Nepcon Malaysia 2015 June 9-11, 2015 Malaysia	Sourcing ground for components, PCB/SMT, semiconductor, testing & measurement and support services sectors in Malaysia	NEPCON Malaysia Phone: +65 6780 4613 Email: nepcon@reedexpo.com.my Website: www.nepcon.com.my/Home/
IFSEC International 2015 June 16-18, 2015 London, UK	The global stage for security innovation and expertise	IFSEC International Website: www.ifsec.co.uk/
AUTOMATION 2015 August 24-27, 2015 Hall No.1 & 5, NSE-Mumbai, Mumbai	Catering to industrial automation, robotics, drives and controls, logistics, hydraulics and pneumatics, and building automation	IED Communications Ltd Phone: 91-22-22079567, 22073370 Email: jyothi@iedcommunications.com Website: www.iedcommunications.com/index.php
IFA Berlin September 4-9, 2015 Berlin, Germany	World's leading trade show for consumer electronics and home appliances	Messe Berlin GmbH, Messedamm 22 Phone: +49-30-3038-2217 Email: vonderropp@messe-berlin.de Website: http://fb2b.ifa-berlin.com
electronica India September 9-11, 2015 Pragati Maidan, New Delhi	Fair for electronic components, systems and applications, besides communication platform for the electronics industry	MMI India Pvt Ltd Phone: +91-9819418496 Email: kavita.chhatani@mmi-india.in Website: www.electronica-india.com/en/home.html
Taitronics 2015 October 6-9, 2015 TWTC Nangang Exhibition Hall No.1, Nangang District, Taipei, Taiwan (R.O.C.)	Electronic components and parts, meters and instruments, LED lighting and applications, power supplies, industrial process and automation, smart living and consumer electronics, broadband products and Cloud	TAITRONICS 2015 (41st Taipei International Electronics Show) Website: www.taitronics.tw
OSI Days 2015 November 19-20, 2015 Nimhans Convention & Exhibition Centre, Bengaluru	Open source conference that aims to nurture and promote the open source ecosystem in Asia	EFY Enterprises Pvt Ltd Phone: 011- 26810601/2/3 Email: info@osidays.com Website: www.osidays.com
LED Expo 2015 December 3-5, 2015 Pragati Maidan, New Delhi	The country's no 1 exhibition on LED Lighting Products and Technologies	Messe Frankfurt Trade Fairs India Pvt Ltd Phone: +91 22 6144 5900 Website: www.theledexpo.com

Look up under 'Events' section in www.electronicsforu.com for a comprehensive list

Since this information is subject to change, all those interested are advised to ascertain the details from the organisers before making any commitment.

42 per cent of total exports, but have been facing constraints in accessing credit facilities.

Market development assistance, interest subsidy certificate scheme and credit-linked capital subsidy scheme are some of the programmes being implemented for the MSME sector.

LED lighting market on high-growth path

According to 6Wresearch, India's LED lighting market is projected to reach US\$ 2.2 billion by 2021. LED lighting market in India is in its nascent stage; however, high growth is anticipated due to government initiatives to replace incandescent bulbs with LED bulbs in streetlight application. Also, with growing awareness and reduction in prices, the market for LED lighting is expected to attain tremendous growth in the forecast period.

Additionally, with government initiatives to promote domestic manufacturing, prices are expected to decline further, thus boosting the growth of the market. The government of India's announcement regarding the distribution of LED bulbs at subsidised rates would further drive the adoption in the country.

In the coming years, as the concept of green building and smarthomes increases, demand for LED bulbs is likely to surge, which would bolster the growth of the market, especially in outdoor and indoor applications.

Haryana solar power policy boosts renewable energy sector

Haryana government has embarked upon an ambitious plan to exploit renewable energy sources like solar, biomass and small hydro for generation of power. The state is endowed with high solar radiation levels with almost 320 days of clear sun each year.

Haryana chief minister, Manohar Lal Khattar, has said that this move would generate 200MW of solar power and would subsequently lead to savings of ₹ 1.51 billion on coal and water consumption.

Snippets

Airtel to double 4G network by next fiscal

Flushed with an investment of US\$ 3 billion a year on networks, telecom major Bharti Airtel plans to double its 4G network by next fiscal. The company will be rolling out mobile tower sites to use its 20MHz broadband wireless access spectrum.

BMW Motorrad to assemble bikes locally

Although BMW Motorrad is yet to enter India officially, the company is looking at locally assembling the bikes (starting with BMW F700 and F800 GS) at its Chennai plant. The move will allow the company to price its bikes competitively, thanks to the lower taxes on local assembly.

IET India launches IoT panel in Bengaluru

Leveraging its position as a multi-disciplinary organisation, Institution of Engineering and Technology (IET) India has launched its Internet of Things (IoT) panel in Bengaluru. The panel, chaired by Dr Rishi Bhatnagar, VP and global head, Digital Enterprise Services, Tech Mahindra, aims to be a neutral, authoritative and credible voice for the evolving movement of IoT in India.

Home Ministry to replace floodlights with LEDs on India-Pakistan border

Taking a cue from PM Modi's pitch for energy-efficient LED bulbs, home minister, Rajnath Singh, has decided to replace all floodlights on the volatile India-Pakistan international border with LEDs.

To encourage private investment in the renewable energy sector, the government has announced investor-friendly policies. Under the Haryana solar power policy 2014, the state aims to install grid-connected solar power across the state. This move would also help in generating employment for the youth.

Yamuna Expressway could soon become an electronics manufacturing hub

The Yamuna Expressway, which connects Delhi to Agra, is soon expected to serve as the electronics manufacturing hub for the country and hence, can give a major push to the Modi government's 'Make in India' campaign.

According to a recent report published by the Times of India, around 12 major companies from countries like Japan, Korea and China have shown keen interest in setting up their manufacturing units along the expressway. In fact, these companies have already sent their delegates to explore some favourable sites in the area for this purpose.

P.C. Gupta, CEO of Yamuna Expressway Industrial Development Authority, said that some of the deals with these big players are already in advanced stages and a couple of these are expected to be concluded

very soon. Even though he has refused to reveal names of these companies, he has said that they are involved in the business of mobile phones, LED lights, televisions, solar pumps and auto parts, among others.

MyGov version 2.0 launched

The government's crowdsourcing platform MyGov.in launched its version 2.0, with newer features such as hashtags, polls, interactive discussion forums and social media account integration. This new, sleeker version will make extensive use of analytics and data mining tools.

MyGov.in chief executive, Gaurav Dwivedi, has said that this new version of the portal would contain opinion polls related to policy issues, detailed surveys to supplement field data collection and collaborative writing for white papers across different ministries and government departments.

MyGov 2.0 has been built on open source technology by National Informatics Centre, and has been an important interface for the government to interact directly with citizens. The portal regularly hosts competitions and discussions on a host of pressing issues in the country, in addition to inviting suggestions for its upcoming activities.

Chinese firms to set up manufacturing units in India

Chinese companies are keen to participate in the Make in India campaign and establish manufacturing facilities in the country, according to China's ambassador, Le Yucheng.

The Ambassador says that Chinese investments here will help address India's concern of mounting trade deficit. India's trade deficit with China rose to US\$ 37.8 billion in 2014 even as bilateral trade picked up, totalling US\$ 70.59 billion, a year-on-year increase of 7.9 per cent.

Sony to start fresh manufacturing in India

Japan based technology company, Sony, has announced that they would soon be opening a factory in India to manufacture mobile phones and televisions. The facility would also be used for markets in Africa and the Middle East.

Head of Sony's Indian operations, Kenichiro Hibi, has said that, keeping in mind the incentives announced in the budget on local production, the company has been motivated to look into opportunities immediately.

Currently, Sony imports all its products in the country from Thailand, Malaysia, China and Japan. Earlier the company used to manufacture in India but the unit was shut down in 2004. At that time the local production was not much justified, and the company found it more convenient to source products from cheaper locations.

Su-Kam Power Systems installs 50kW grid-tie systems

Su-Kam Power Systems Ltd has installed 50kW grid-tie systems for Delhi Jal Board. The company has bagged this project after winning a tender from Delhi State Industrial and Infrastructure Development Corp. Ltd (DSIIDC).

As part of this project, Su-Kam will install two grid-tie inverters of 25kW each and 200 PV modules of 250W each. The installation will generate 90,000 units of electricity per year, thereby helping Delhi Jal Board to save ₹ 720,000 annually.

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MARKET SURVEY:

Green Power Backup Solutions will be the Next Big Thing in India



Abhishek A. Mutha
is a senior technical
correspondent at EFY

With focus steadily increasing on renewable energy, the uninterruptible power supply (UPS) and inverter industry is slowly coming up with systems that are compatible with various renewable energy sources. Manufacturers are also investing on creating products that are energy-efficient, highly reliable and robustly designed with a lower total cost of ownership. Let us take a look at the drivers of the industrial power backup industry, products in demand, market trends, government policies and industry experts' views on the future of this segment.

Growth factors

The foremost and primary driver of industrial UPSes and inverters is severe power deficit and the consequent frequent power cuts across the nation. Unpredictable power cuts have become a major concern for the corporate sector, feels Moumita Mukherjee, research analyst, Netscribes. She says, "Currently, dedicated power grids to meet domestic and industrial power needs do not exist in India, as a result of

which some key segments like e-commerce and data centres rely completely on uninterrupted power backup."

It would be fair to state that UPSes and inverters have a good market share in India because of the non-availability of a strong grid system. UPSes are required in offices where computers or servers are stationed and uninterrupted power is needed. "If computers and servers go down for even a minute, it creates a lot of problems for organisations dependent on these," says R. Sivarajan, R&D head, Su-Kam. He adds, "The reason for UPSes to be used for high-priority applications is because there is no transfer time required." It is also advantageous for internal lighting loads, fans, coffee machines and other appliances.

Anindya Das, industry manager, Energy & Environment Practice, Frost & Sullivan, says, "Sizeable demand from information technology (IT)/information technology enabled services (ITeS), banking, financial services and insurance (BFSI), government, infrastructure, healthcare, education and manufacturing sectors are driving the UPS market in India." Also, almost every business is connected with the Internet. A lot of trading activities also happen via the Internet.

"Servers host all data and if it is not backed up by UPS, it puts the data at risk," says Sivarajan. "From small-scale entrepreneurs to large multinationals and conglomerates, it is very important that all corporates having critical data hosted on servers must be protected by UPS," he adds.

In sectors like IT/ITeS and BFSI, investment in power backup systems comes from major corporate consumers like TCS, Cognizant and Tech Mahindra, informs Chandrashekhar Prakash Rao, sales director, Secure Power for Industry & Infrastructure, Schneider Electric. These require UPS and inverter systems for their enormous campus-



es, development centres and business process outsourcing (BPO) establishments in India. He says, "If you look at telecommunication as a segment, telecom network infrastructure roll-outs like 3G or 4G are the major driving factors for Telco." He adds, "With rolls-out, multinational companies come up with main switching centres, distribution centres or data centres that require power backup."

The broadening gap between demand and supply of power is another key factor for the growth of industrial inverters and UPSes. Fast-growing industrialisation, which has a positive aspect of the country's economic growth, comes with a difficult concern for the demand to keep pace with the growing infrastructure.

According to Malvika Sood, senior technical sales engineer, Texas Instruments India Pvt Ltd, the present inverter market in India produces about seven to eight million inverters per year and the growth is five to six per cent per year. She says, "Earlier the business was focused mainly on tier I and tier II cities. Now, with improved power situation in India, focus is also shifting to rural India." She adds, "As per McKinsey & Company's analysis report, total demand for power will rise from 120GW to 315GW by 2017. As the inverter industry thrives on shortage of power, this is the area where UPS markets have the greatest potential and see a speedy growth."

Today, the corporate sector's presence is not only felt in urban cities but is slowly trickling down into smaller towns as well, informs Sivarajan. He says, "The power scenario in developing cities and towns is not very promising." Das too feels that the increasing penetration of IT/ITeS sector in tier II cities has boosted the UPS and inverter market.

Low-harmonics, high-efficiency and wide-power-range products in demand

With respect to the corporate and industrial sector, it is the high power range of UPS systems that primarily

experiences the maximum demand, informs Moumita Mukherjee, research analyst, Netscribes. There is also a high demand for systems where customers can assess the total cost of ownership, which helps them reduce additional expenses in the long run.

Rao says, "Low harmonics and high efficiency are some other sought-after specifications. UPSes and inverters that contribute to a clean environment are also in demand." He adds, "Gone are the days

Growth factors at a glance

- Power deficit and the consequent frequent power cuts
- Unstable power grid
- Rapid industrialisation
- Telecom network infrastructure roll-outs
- Penetration of IT/ITeS sector in tier II cities

where customers looked for preventive maintenance. Today, customers expect vendors to give some element of predictability, with respect to harmonics, in UPSes and inverters."

The UPS market is slowly moving towards transformerless and modular UPS systems, notes Das. This is mainly due to space constraints and rise in Leadership in Energy & Environmental Design (LEED) certification in buildings. He says, "Initially, inverters were used to operate fans and lights but now these are designed to run desktops, air-conditioners and other household appliances."

The industry is also looking towards setting up offices and factories more efficiently. Sood says, "Products with high efficiency (about 80 to 90 per cent) are in demand, which is met by sine-wave inverters. Consumers are not only asking for higher-efficiency products but are looking to save power as well."

She adds, "There is also notable rise in demand for solar inverters, which not only cultivates natural resources during the day but also charges batteries to supply power at night. Lower-rating solar inverters, also called hybrid inverters (com-

bination of solar panel and inverter) of up to 500W or so, are available as catalogue products with tier I inverter manufactures." Higher-rating products are customised as per the requirement from the industry.

Multinationals dominate UPS segment, Indian companies have the edge over inverters

Analysts and industry experts feel, multinationals like Schneider Electric and others rule the UPS market in

India today and Indian players do not have a great market share. Indian companies are also trying to supply products with the same kind of reliability as required by corporates.

Inverter-operating conditions are slightly stringent, given the power condition in India. Products made locally are completely based on the experience that manufacturers have with local grids. "For instance, the grid in the USA or Europe is completely stable. Their inverter systems need not be as rugged as the ones made for Indian conditions, where the frequency could go below 45Hz or above 55Hz for a 50Hz grid," explains Sivarajan.

He adds, "Standard voltage of 230V in India can dip to as low as 110V or 120V. Therefore power backup systems for usage in India need to be designed keeping such conditions in mind. Indian companies like Su-Kam try to understand grid-voltage levels and other conditions in cities and villages, and design systems accordingly."

Market trends

In the recent past, there has been a rise in consumers' growing affinity towards high power, cost-effectiveness and energy-efficiency. Mukherjee says, "With a continual rise in awareness about eco-friendliness, Green UPS technology is gradually gaining momentum in India."

Customers are willing to experiment with new technologies. Rao informs, "For instance, in the IT

industry, they are opting for high-end insulated-gate bipolar transistor (IGBT) UPSes, which offer low harmonics and high power factor. They are also keen on reducing the carbon footprint and operating expenses by a target percentage set by themselves.”

Earlier, in rural sectors, people were tolerant towards long power cuts. However, there has been a change in the behaviour pattern of people as they are now opting for backup solutions, notes Sood. She says, “People are also demanding efficient systems and the trend is shifting to solar-powered systems with maximum power point tracking (MPPT).”

Rao feels, customers have still not seen the actual benefit of solar inverters. He says, “It has a prolonged payback period of more than 10 years. Maybe three or five years down the line, we can expect solar inverters to trend but at this stage solar inverters are not in major demand.”

On the other hand, Sivarajan notes, “When you are investing on a 500VA or 800VA solar inverter, the payback period might be a little longer but a solar panel lasts for a minimum of 25 years. Even if you are getting the return on investment after five years, it is still worth it.” He adds, “Consumers are already reaping the benefits of solar inverters.”

According to Rao, three- and four-level inverters are quite the trend in the market today. He says, “These inverters achieve very high switching speeds, low harmonic distortion and high reliability with a compact footprint.” Maintenance is a key parameter that consumers consider today while choosing a secure power solution. He adds, “Advanced battery-management solutions and fire-proof batteries are some other trends in the UPS and inverter industry.”

Three-level inverters are inverters with three levels of switching. Sivarajan says, “These provide slightly greater efficiency and nothing more than that.” He adds, “The end customers, that is industrial or corporate users, do not exactly understand three- or four-level inverters. They look for a

The increasing penetration of IT/ITeS sector in tier II cities has boosted the UPS and inverter market

reliable power system that gives them backup whenever required.” At the end of the day, the technology that the customer chooses has to serve the purpose of reliability.

Battery indicators in power backup systems is another trend picking up in the market to make the consumer aware of the battery life status. Sood says, “This is possible with inverters having battery management systems in place. Such solutions are already available in the market with tier I suppliers.” She adds, “All inverter manufactures are also looking to reduce the size of inverters by switching to high-frequency inverters. Such inverters would require smaller-size transformers, and will also help in reducing the overall cost other than improved efficiency.”

Talking about high-frequency inverters, Sivarajan claims, “We have launched a new high-frequency inverter that has an efficiency of more than 90 per cent. If you consider a regular transformer based inverter, it provides a maximum efficiency of 80 to 82 per cent.” He adds, “Technology is playing a heavy role in minimising the losses in inverters for better conservation and battery life.”

Government policies

Recently, the solar energy sector was in for good news on the first day of the new year, as the Haryana government has issued a directive to have rooftop solar power system installed in every building of the plot size of 418.06sqm (500-square yards) or more. Systems are to be installed by September 2015, informs Sood. She says, “The order will be applicable to private bungalows, group housing societies, builder apartments, malls, offices, commercial complexes, schools, hospitals (any building, new or old,

that meets the plot-size criteria).” She adds, “Adding to the incentives for developers, the government will offer a 30 per cent subsidy on installation costs on first-come-first-served basis.”

Also, with several state governments in India promoting the usage of solar power by announcing several policy changes, the hospitality and retail industry has shown early signs of adoption. Mukherjee says, “A number of vendors are working on solutions based on solar power. It will be interesting to observe the rest of the industrial community in India responding to solar-powered UPSes and inverters.”

In some states, if a UPS that gives very high power factor to the source is deployed by manufacturing plants, IT organisations and other industrial facilities, the state incentivises their electrical consumption, informs Rao. He says, “There are also regulations coming from electricity boards to maintain the harmonics within certain limits. For a clean electricity environment, it is necessary for UPS manufacturers to adopt technologies such as IGBT. This benefits customers by not inducing high amount of harmonics to the source.” He adds, “Our recommendation to the government would be to restrict measurable parameters, such as harmonics, to five per cent on the input side and power factor to 0.95.”

Adding to the recommendations, Sivarajan says, “I would like the government policies to be ‘Make in India’ friendly so that Indian companies into manufacturing power backup hardware systems can benefit from better taxation system, infrastructure and road transportation system. There should be a simplified taxation system for a business to grow in India.” “The initiatives towards building infrastructure to promote hardware industry from the new government looks good but it is too early to rate these,” he adds.

Pricing trends

Prices of commodity items like copper, aluminium and steel are only increasing, so there are always challenges to keep the product competitive, feel

MAJOR CONTRIBUTORS TO THIS REPORT



Anindya Das,
industry manager,
Energy & Environment
Practice, Frost &
Sullivan



**Chandrashekhar
Prakash Rao**,
sales director, Secure
Power for Industry
& Infrastructure,
Schneider Electric



Malvika Sood,
senior technical
sales engineer, Texas
Instruments India
Pvt Ltd



**Moumita
Mukherjee**,
research analyst,
Netscribes



R. Sivarajan,
R&D head,
Su-Kam

industry experts. Sivarajan says, “The cost of semiconductor is falling every day, be it microcontrollers, metal-oxide-semiconductor field-effect transistors (MOSFETs) or IGBTs, which impacts the overall pricing of power backup systems.”

“We cannot continue using power backup systems with older technology. Prices of products incorporating newer technology will be on the higher side in initial stages, but the advantages these will offer will prove tremendous later,” he adds.

Indian inverter market is divided into sine-wave and square-wave inverters. Sood notes, “North India is price conscious and [people here] go for square-wave inverters, which typically cost around ₹ 4000, whereas South India is more technology conscious and [people there] opt for sine-wave inverters, which cost around ₹ 4500.”

Powerful future for UPS and inverter industry

The future of the UPS and inverter market, especially in the industrial segment, seems bright. There is traction towards renewable energy systems like solar inverters and converters. Sivarajan feels, “In the coming years, we must shift our dependency to solar instead of generating more power from non-renewable sources.”

Bureau of Indian Standards (BIS) and Bureau of Energy Efficiency (BEE) standards, which focus on safety and efficiency of inverters, are still to be implemented. Sood says, “With BEE standards, demand will

slowly decline for square-wave inverters. Also, with new government policies and subsidies being offered, solar systems will be gaining momentum in the market.”

She adds, “Renewable systems see a very huge growth potential in the corporate inverters market. Although inverter companies are already working towards this solution, there should be policies in place for encouraging development of inverters that will feed back power to the grid.”

The per capita consumption of electricity in India is about 1000kWh and the worldwide consumption is 2600kWh. Even as power generation increases, demand is bound to increase in India, feels Sood. She says, “As power conditions improve, we do not foresee that electricity will be available 24 hours in near future. We will also see more people using hybrid inverters, which are a combination of solar and grid power to provide optimal use.” She adds, “Inverters in future will not only help create backup for devices but will also be smart enough in order to manage power.”

Sivarajan feels, the future will move towards direct current (DC) systems. “Traditional inverters converting DC to alternating current (AC) have their own conversion losses. Complete home lighting and fan application will be driven towards DC for the higher efficiency and safety these provide.” He adds, “Lighting will be on light emitting diodes (LEDs), which run on DC and we will have DC fans in ceilings.” ●



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COMPONENTS

Driver

Quaser Electronics, under its brand of QLITE, has launched a highly-reliable, active power factor corrected (>0.95) driver for 24W, constant current 500mA applications. The input voltage range is 110V AC to 265V AC, and the driver size is $101 \times 53 \times 36$ mm. The high efficiency (>88 per cent) of the driver is maintained by using high-quality driver components. The driver has features like short circuit protection and overload protection.

Quaser Electronics Pvt Ltd

Email: info@qlite.in

Website: www.qlite.in

Power entry module

SCHURTER's power entry module is now equipped with an additional ground line choke to suppress high-frequency interference arising from ground loops on the ground line. The choke also improves asymmetric attenuation in higher frequencies in medical-filter versions.



The module includes an IEC C14 power inlet connector with a one- or two-pole fuse holder and EMC filter. The series offers current levels from 1A to 10A at 250V AC, according to IEC and UL standards. It has ENEC and cURus approvals and is suited for applications according to IEC 60950. Special filter

versions, M5 and M80, are available for medical devices according to IEC 60601-1. Wiring is done using quick-connect terminals or wire leads. The KFA is compatible with V-lock cord sets, designed to safeguard against unintentional disconnection of power.

SCHURTER Electronics (India) Pvt Ltd

Website: www.schurter.co.in

TEST & MEASUREMENT

Multimeter

GDM-8351 is developed to upgrade the features of the existing $5\frac{1}{2}$ -digit digital multimeter, GDM-8251A, at a more competitive price.



New features include fast measurement speed of 320 readings/s, capacitance measurements, 6V high-power LED measurements and USB TMC support. GDM-8351 inherits all good features of GDM-8251A, including VFD dual-display, maximum 120,000 counts, 0.012 per cent basic DC voltage accuracy and USB/RS232C connectors to provide users with measurement precision, lucid data observation and convenient connection with the PC.

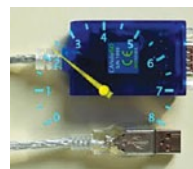
GW Instek

Website: www.gwinstek.com

Analyser

CANdoISO is a compact, isolated USB to CAN interface, that allows a PC to be connected directly to an embedded CAN bus. In conjunction with the free CANdo application software, CANdoISO provides a simple, yet powerful means of testing and analysing a CAN network. The free

CANdo SDK allows CANdoISO to be easily integrated into any Windows based program.



The USB and CAN ports are separated by a 500V-rated isolation barrier. This isolation barrier prevents any harmful ground currents flowing in cases where there is, or maybe, a difference in the ground potential between the PC and CAN bus.

Uchi Embedded Solutions

Email: sales@uchiembedded.co.in

Website: www.uchiembedded.co.in

RF generator and detector

This specialised RF signal generator and detector by Akademika is designed for the education segment, covering a frequency range from 35MHz to 3GHz. It is an accurate and stable product with multiple modes of operation and has modulation capabilities (AM, FM and PSK).

The architecture uses a highly-accurate and stable PLL synthesiser based frequency generator with dou-



ble harmonic suppression capability having low phase noise. The RFGD system employs inbuilt high dynamic log detector arrangement for forward and reflected power measurement. The device is compatible for an external RF sensor probe (50-ohm) and RF antenna to estimate unknown signal mapping. An SMA connector provides output for full span with ad-

justable output power from -30dBm to +0dBm into a 50Ω load.

BNC-type inputs are available at the rear end of the equipment to connect modulating signals. The system is interfaced with the PC using a USB port and GUI provided on LabVIEW platform to monitor, control and plot records.

Akademika Lab Solutions

Website: www.akademika.in

POWER SUPPLY

Solar hybrid UPS

The smart solar hybrid UPS is built on a DSP based processor with built-in smart features. The product comes with an LCD display that shows not



only voltage and current but also the load consumed in watts from the UPS. It has a built-in integrated charge controller, which is a zero drop current controller.

It automatically selects solar charge option when the sun is out. When the battery is fully charged and the load is on mains and solar charging is possible, it automatically switches to UPS mode and discharges the battery up to 30 per cent and simultaneously charges it on solar power. After the battery is discharged 30 per cent, it again switches back to mains mode automatically. This feature enables power saving when there are no power cuts or when batteries are lying idle.

Elektro Power Systems

Phone: 080-41646969, 22484666

MISCELLANEOUS

Gas leak indicator

Subtronics has introduced industrial gas monitors that offer faster signal processing, higher accuracy and



wider coverage area. These can detect a range of more than 300 gases. Prominent features include three status technology, 100 per cent compatibility with your existing system, PLC, DCS, SCADA or any annunciator panel, flexible mounting options.

Subtronics (India) Pvt Ltd

Email: service@subtronicsindia.com

Website: www.subtronicsindia.com

LAN/WAN module

The RN2483 comes with the LoRaWAN protocol stack, so it can easily connect with the established and rapidly-expanding LoRa Alliance infrastructure, including both privately-managed local area networks (LANs) and telecom-operated public networks, to create low-power wide area networks (LPWANs) with nationwide coverage. This stack integration also enables the module to be used with any microcontroller that has a UART interface, including hundreds of Microchip's PIC MCUs. Additionally, the RN2483 features Microchip's simple ASCII command interface for easy configuration and control.

Microchip Technology Inc.

Website: www.microchip.com

Thermal camera

FLIR has announced the release of FLIR C2, the first full-featured, pocket-sized thermal camera designed to help professionals find

and see hidden heat patterns that can clearly show where problems are, such as sources of overheating electrical connections and more. Its compact and slim design enables the C2 to fit comfortably into any pocket,

The C2's 4800-pixel resolution, high-sensitivity detector captures and displays subtle thermal patterns and small temperature differences useful in electrical and HVAC applications, and a wide 41° field-of-view frames in more of the scene. The C2 includes a built-in worklight and flash that helps illuminate poorly-lit areas, common in various inspection environments. The extra illumination also ensures that a brighter visible photo is able to be captured along with C2's thermal image.

FLIR Systems India Pvt. Ltd

Website: www.flir.com

Wireless battery charger controller

The STWBC digital controller for wireless battery charger (WBC) transmitters from STMicroelectronics offers the most flexible and efficient solution for controlling power transfer from a WBC transmitter (TX) to a receiver (RX) in WBC-enabled phones, wearables and other battery-powered devices that use electromagnetic induction for recharge.

The STWBC performs all essential functions for transmitter control. It can precisely control the amount of transmitted power to match the requirements of the receiving unit in terms of maximising the efficiency of the power transfer and minimising any increase in the operating temperature. The digital feedback between TX and RX units allows detection of metal objects close to the receiver (foreign object detection) that could result in potential disasters, enabling the STWBC to stop power transmission when such objects are detected.

STMicroelectronics

Phone: +91-120-2352999

Website: www.st.com

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Products	Page No.	Products	Page No.	Products	Page No.	Products	Page No.
Automation & Robotics		Universal Electronic Agencies	130	Optics & Optoelectronics		Gurukirpa Electronics	144
Bhasha Technologies Pvt. Ltd	107	Components (Including Active & Passive)		Binay Opto Electronics Pvt Ltd	16	Martin's Electronic Devices & Instruments	138
Jai Mata Electronics	140	Circuit Electro Components P Ltd	138	Buljin Elemec Pvt Ltd	139	Nehatronics	143
ST Microelectronics Marketing Pvt. Ltd	41	ConinsPune	138	GSR Infocom Pvt. Ltd.	140	Shreyansh Electronics	144
Toradex Systems (India) Private Limited	11	Digi-Key Corporation	3	International Corporate	140	Systellar Innovations	132
Batteries & Power Supplies		Element14 India Pvt Ltd.	1	Key Operations & Electrocomponents Pvt Ltd ...	53	Switches & Relays	
Arham Electronics & Electricals		Laxmi Electronics	144	Lightronics	130	Electronics Relays (India) Pvt Ltd	132
(Nimra Products)	144	LWI Electronics Inc.	23	Micro Controls	139	PIC GmbH	47
Arrow Electronics India Pvt Ltd	17	Max Electronics	144	Rockforest	139	Telecom Products	
BB Battery India Co. Pvt Ltd	25	Millenium semiconductors	13	PCBs, Assemblies & Sub Assemblies		Matrix Comsec Pvt Ltd	9
Coslight India Telecom Pvt. Ltd.	130	Momsun Guangzhou Science &		Buljin Elemec Pvt Ltd	139	Tenders & Announcements	
Digital Promoters (I) Pvt Ltd	139	Technology Co. Ltd.....	85	Circuit Systems (I) Ltd	53	Test & Measurement Equipment	
Eita Technologies	140	Mouser Electronics (Hong Kong) Ltd	7	Plugs, Sockets & Connectors		(Including Indicators & Monitors)	
Elektro Power Systems	145	Perfect Radios	140	Rank Infotech	136	Dintek	140
Elnova Ltd	140	Renesas Electronics India Pvt. Ltd.	71	Reseller and Distributors		FLIR Systems	39
Gurukirpa Electronics	144	S.M Semiconductors	143	Digi-Key Corporation	3	Good Will Instrument Co. Ltd	150
Indus Industries	135	Takiar Overseas (P) Ltd	144	Element14 India Pvt Ltd.	1	Keysight Technologies India Pvt. Ltd.	2, 5
Jai Mata Electronics	140	Trade Corp.	143	Laxmi Electronics	144	NI Systems (India) Pvt Ltd	151
Kandhari Photo Electronics P Ltd	143	Display Systems		LWI Electronics Inc.	23	Tektronix India Pvt Ltd	152
Maxwatt electronic Corporation	144	Electronic Assembly	85	Mouser Electronics (Hong Kong) Ltd	7	Trade Shows and Events	
National Controlling & Equipments	140	Educational Training Kits		Sensors & Transducers		IED Communications Ltd	134
Nippon India	135	Minmax Electronics	139	PIC GmbH	47	NEPCON Japan	51
Perfect Systems	145	ISOFT	136	Rhydo Technologies P Ltd	129	NEPCON Malaysia 2015	81
PSI Enterprises	139	Industrial & Manufacturing Equipment		Services		NI Systems (India) Pvt Ltd.....	151
Sakthi Accumulators Private Ltd	140	Max Technology & Co.	35	Pulraj Electronics Pvt Ltd	49	Training and Certification Institutes	
Shavison Electronics Pvt. Ltd.	113	Materials (Including Chemicals & Consumables)		Solar Products		CADD Centre Training Services	
Srishti Electronics	143	DELTA Magnets Ltd	19	Arham Electronics & Electricals		Private Limited	133
Stab-Brain Systems	143	HK Wentworth (India) Pvt Ltd	45	(Nimra Products)	144	Perfect Electronics	143
Trontek Electronics Pvt. Ltd.	131	Hybrid Metals Pvt Ltd	134	Aura Emergency Systems	145		
Cabinets, Enclosures & Accessories		Persang Alloy Industries Pvt Ltd	137	Elektro Power Systems	145		
Chhabra Electronics	139	Progressive Engineers	136				
L K Enterprises	139						
S K Metal Works	14						
Shrey Plastic Moulders	143						

EFY Magazine Attractions During 2015

MONTH	TECHNOLOGY FOCUS	MARKET SURVEYS	BUYER'S GUIDE FOR ELECTRONICS LABS
January	IoT & Big Data	LED Lighting	Programmable Power Supplies
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October	Robotics & Automation (Smart Machines)	Solar Electronics	Latest Tools to Manage ESD for Your LAB
November	Renewable Energy	Industrial Automation	Desktop PCB Manufacturing Equipment
December	Smart Lighting	LCD Display Components	Programmable Power Source

ADVERTISERS' INDEX

Client name	Page No.	Client name	Page No.	Client name	Page No.
Arahm Electronics & Electricals (Nimra Products).....	144	Good Will Instrument Co. Ltd (www.goodwill.com.tw).....	150	NI Systems (India) Pvt Ltd (www.ni.com).....	151
Arrow Electronics India Pvt Ltd.....	17	GSR Infocom Pvt. Ltd.....	140	Nippon India (www.nipponindia.com).....	135
Aura Emergency Systems.....	145	Gunuripa Electronics.....	144	Open Source India.....	140, 147
BB Battery India Co. Pvt Ltd.....	25	HK Wentworth (India) Pvt Ltd.....	45	Perfect Electronics (www.perfectelectronics.net).....	143
Bhasha Technologies Pvt. Ltd (www.bhashatech.com).....	107	Hybrid Metals Pvt Ltd.....	134	Perfect Radios.....	140
Binay Opto Electronics Pvt Ltd (www.binayLED.com).....	16	IED Communications Ltd.....	134	Perfect Systems.....	145
Buljin Elemec Pvt Ltd.....	139	Indus Industries.....	135	Persang Alloy Industries Pvt Ltd (www.persangalloy.com).....	137
CADD Centre Training Services Private Limited.....	133	International Corporate.....	140	PIC GmbH (www.pic-gmbh.com).....	47
Chhabra Electronics.....	139	ISOFT.....	136	Progressive Engineers.....	136
Circuit Systems (I) Ltd (www.mysil.com).....	53	Jai Mata Electronics.....	140	PSI Enterprises.....	139
Cirkut Electro Components P Ltd.....	138	Kandhari Photo Electronics P Ltd.....	143	Pulraj Electronics Pvt Ltd (www.pulraj.com).....	49
Conins Pune.....	138	Key Operations & Electrocomponents Pvt Ltd.....	53	Rank Infotech (www.rankinfotech.com).....	136
Coslight India Telecom Pvt. Ltd.....	130	Keysight Technologies India Pvt. Ltd. (www.keysight.com).....	2, 5	Renesas Electronics India Pvt. Ltd.....	71
DELTA Magnets Ltd.....	19	Kits 'N' Spares.....	109	Rhydo Technologies P Ltd (www.rhydo.com).....	129
Digi-Key Corporation (www.digikey.com).....	3	L K Enterprises (www.lkeindia.com).....	139	Rockforest.....	139
Digital Promoters (I) Pvt Ltd.....	139	Laxmi Electronics.....	144	S K Metal Works (www.skmetals.com).....	14
Dintech.....	140	Lightronics (www.lightronics.in).....	130	S M Semiconductors.....	143
EFY Group: EFY EB Google Ad.....	67	LWI Electronics Inc. (www.livewireinfo.com).....	23	Sakthi Accumulators Private Ltd.....	140
EFY Group: EFY Expo India.....	30, 31	Martin's Electronic Devices & Instruments.....	138	Shavison Electronics Pvt. Ltd. (www.shavison.com).....	113
EFY Group: electronicsforu.com.....	142	Matrix Comsec Pvt Ltd (www.cognitoidia.com).....	9	Shrey Plastic Moulders (www.shreyplasticmoulders.com).....	143
EFY Group: eZine.....	61	Max Electronics.....	144	Shreyansh Electronics.....	144
EFY Group: IIT Madras.....	121	Max Technology & Co. (www.maxtechnoiindia.com).....	35	Srishti Electronics (www.acedigital.co.in).....	143
EFY Group: Response Guarantee.....	77	Maxwatt electronic Corporation.....	144	ST Microelectronics Marketing Pvt. Ltd.....	41
EFY Group: Subscription Form.....	90, 91	Micro Controls (www.microcontrols.net).....	139	Stab-Brain Systems.....	143
EFY Tech Center.....	12	Millenium semiconductors (www.millenniumsemi.com).....	13	Systellar Innovations (www.systellar.in).....	132
Eita Technologies.....	140	Minmax Electronics (www.minmax.co.in).....	139	Takiar Overseas (P) Ltd.....	144
Electronic Assembly (www.lcd-module.de).....	85	MMI India Pvt. Ltd.....	59	Tektronix India Pvt Ltd. (www.tektronix.com).....	152
Electronics Industry Directory.....	57	Mornsun Guangzhou Science & Technology Co. Ltd.....	85	Toradex Systems (India) Private Limited (www.toradex.com).....	11
Electronics Relays(India) Pvt Ltd.....	132	Mouser Electronics (Hong Kong) Ltd.....	7	Trade Corp.....	143
Elektro Power Systems.....	145	National Controlling & Equipments.....	140	Trontek Electronics Pvt. Ltd.....	131
Element14 India Pvt Ltd.....	1	Nehatronix (www.natashaindia.com).....	143	Universal Electronic Agencies (www.easternradio.co.in).....	130
Elnova Ltd (www.elnova.com).....	140	NEPCON Japan (www.enepcon.com).....	51		
FLIR Systems (www.flir.com).....	39	NEPCON Malaysia 2015.....	81		

Page numbers subject to final dummy corrections

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